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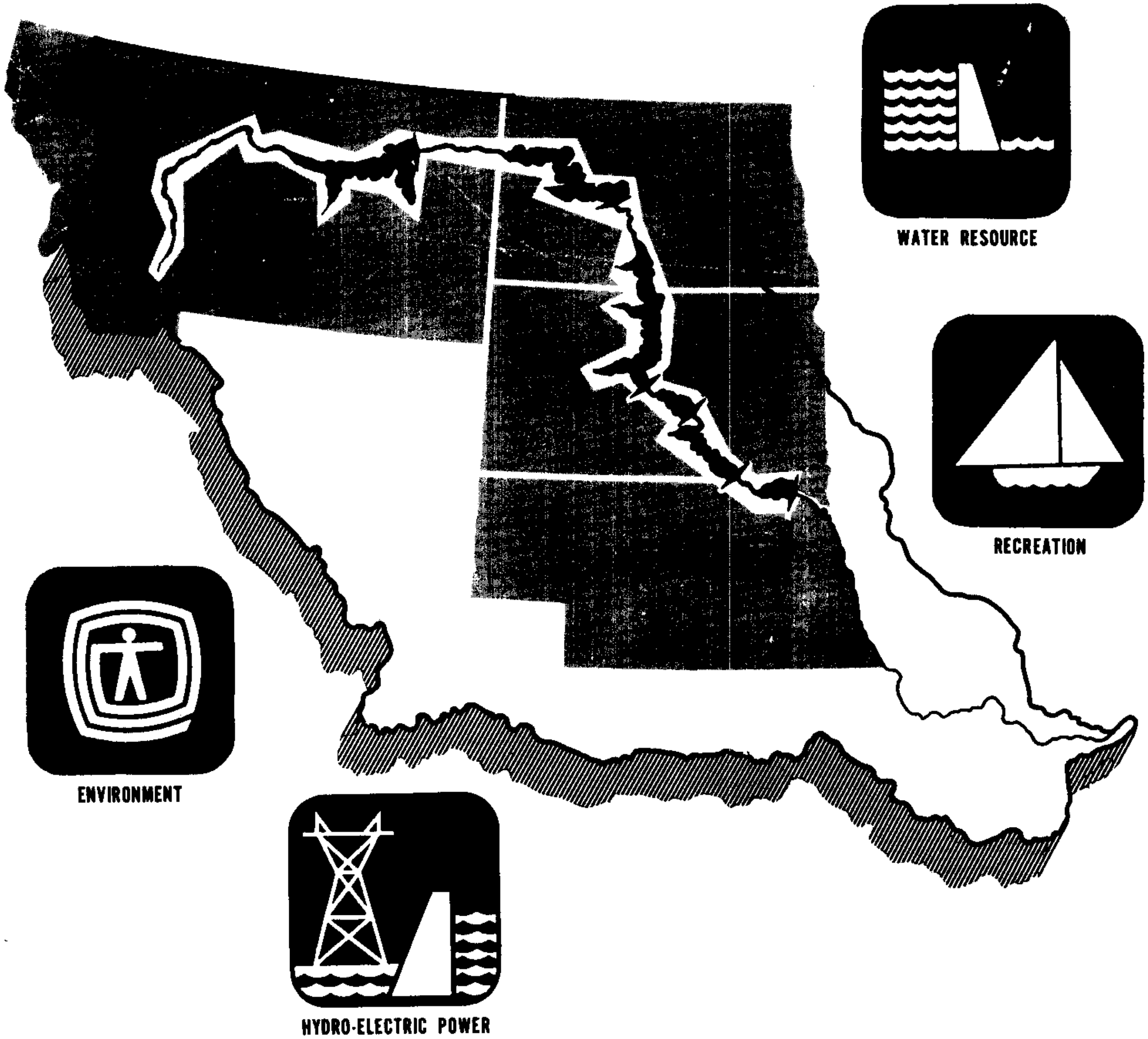
MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

REVIEW REPORT FOR WATER RESOURCES DEVELOPMENT



REVIEW REPORT FOR WATER RESOURCES DEVELOPMENT

APPENDIX 1
TECHNICAL REPORT
VOLUME 2 OF 3

AUGUST 1977

REVIEW REPORT FOR
WATER RESOURCES DEVELOPMENT
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

Technical Report

APPENDIX 1

PREPARED BY THE
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

SECTION A

THE STUDY AND REPORT

THE STUDY AND REPORT

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SECTION A

THE STUDY AND REPORT

1. This section traces the numerous expressions of Congressional interest in the upper Missouri River and their consolidation into a single report. Administrative details concerning coordination with other entities, public participation and a bibliography of prior studies are also provided.

Purpose and Authority

2. The purpose of this study is to investigate a wide range of water resources problems and opportunities all having in common some link with the Missouri River. A number of outstanding, interrelated Congressional actions affecting the river reach upstream from Sioux City have been consolidated under this investigation. Authority to combine five outstanding surveys is contained in Office, Chief of Engineers' (OCE's) first indorsement to Missouri River Division letter of 3 July 1972, subject: "Consolidation of Survey Investigations of the Metropolitan Region of Kansas City, the Platte River in Nebraska, and the Missouri River from Sioux City to Fort

Peck Lake." Authority to include a sixth survey of the Missouri River is contained in OCE's letter of 10 September 1973, subject: "Review Report on Water and Related Land Resources Development for the Missouri River, Fort Peck Reservoir to Vicinity of Fort Benton, Montana." Study of the Buford-Trenton Irrigation District and Vicinity was added by OCE first indorsement to MRD letter of 31 March 1976, subject: "Consolidation of Survey Investigations." Finally, an OCE letter dated 23 March 1977, subject: "Fort Randall Project, South Dakota", directed MRD to combine an outstanding survey investigation on modification of operations at that project with this report.

Study Authorizations

3. The authorities under which this study is made are contained in 15 Congressional resolutions and five items in River and Harbor or Flood Control Acts. These 20 Congressional actions were adopted or approved during the period from 1938 to 1970 and, collectively, are concerned with navigation, bank erosion control, hydro-power, flood control, recreation, fish and wildlife preservation, irrigation, pollution abatement, sediment control, and waterlogging. The study authorizations of this investigation and the text of the resolutions or excerpts from the public laws follow:

- Resolution adopted 18 February 1938. "RESOLVED BY THE COMMITTEE ON RIVERS AND HARBORS OF THE HOUSE OF REPRESENTATIVES, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River submitted in House Document numbered 238, 73rd Congress, 2d Session, with a view of determining if it is advisable, in the interest of navigation and for other purposes, to construct a lock and dam in this river at or near Gavins Point, Yankton, South Dakota."

- Resolution adopted 7 March 1939. "RESOLVED BY THE COMMITTEE ON RIVERS AND HARBORS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors, created under

Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River submitted in House Document numbered 238, 73rd Congress, 2d Session, and previous reports, with a view to determining whether improvement from Sioux City, Iowa, to the vicinity of Chamberlain, South Dakota, in the interest of navigation is advisable at this time."

● Resolution adopted 18 July 1939. "RESOLVED BY THE COMMITTEE ON COMMERCE OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River submitted in House Document numbered 238, 73rd Congress, 2d Session, and previous reports, with a view to determining whether improvement for flood protection and prevention of bank erosion on the main stem of the Missouri River in Knox and Dixon County, Nebraska, is advisable at this time."

● Resolution adopted 2 August 1939. "RESOLVED BY THE COMMITTEE ON FLOOD CONTROL OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River contained in House Document numbered 238, 73rd Congress, 2d Session, with a view to determining what improvement of said river is advisable at this time for flood protection and prevention of bank erosion on the main stem of the river from Sioux City, Iowa, to the point above Niobrara, Nebraska, where the course of the Missouri River is wholly within the State of South Dakota."

● Resolution adopted 19 January 1940. "RESOLVED BY THE COMMITTEE ON RIVER AND HARBORS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River submitted in House Document numbered 238, 73rd Congress, 2d Session, with a view to determining the desirability of improving the river in South Dakota to make power available to develop deposits of manganese and other strategic minerals, and for pumping and other uses."

- River and Harbor Act approved 2 March 1945, Public Law 14, 79th Congress, 1st Session. "SEC. 6. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys to be made at the following-named localities:

  Missouri River in South Dakota and North Dakota

  Missouri River in Nebraska."

- River and Harbor Act approved 24 July 1946, Public Law 525, 79th Congress, 2d Session. "SEC. 7. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys to be made at the following-named localities:

  Gavins Point, on the Missouri River, South Dakota and Nebraska."

- Resolution adopted 18 January 1949. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report on the Missouri River, contained in House Document numbered 238, 73rd Congress, 2d Session, and subsequent reports, with a view to determining the advisability of providing flood control along the main stem of the Missouri River in the reach upstream from Mandan, North Dakota, to a point just below the existing Garrison Dam."

- Resolution adopted 28 January 1955. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River and Tributaries printed in House Document numbered 475, 78th Congress, 2d Session, and other reports, with a view to determining methods of preventing loss of land and irrigation works in the Buford-Trenton Irrigation District, North Dakota, resulting from bank erosion along the Missouri River.

● River and Harbor Act, approved 3 July 1958, Public Law 500, 85th Congress, 2d Session. "SEC. 112. The Secretary of the Army is hereby authorized and directed to cause surveys to be made at the following localities and subject to all applicable provisions of Section 110 of the River and Harbor Act of 1950: Missouri River, with a view to extending nine-foot navigation from Sioux City, Iowa, to Gavins Point Dam, South Dakota - Nebraska."

● Flood Control Act, approved 3 July 1958, Public Law 500, 85th Congress, 2d Session. "SEC. 206. The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes ... to be made under the direction of the Chief of Engineers, in drainage areas .... which include the following-named localities .....

"Missouri River Basin, South Dakota, with reference to utilization of floodwaters stored in authorized reservoirs for purposes of municipal and industrial use and maintenance of natural lake levels ...."

● Resolution adopted 20 April 1959. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports on the Missouri River and Tributaries, published as House Document numbered 238, 73rd Congress, and other pertinent reports, with a view to determining the advisability of providing bank stabilization works in that reach of the river between Garrison Dam, North Dakota and Oahe Dam, South Dakota."

● Resolution adopted 2 February 1960. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River, published as Senate-Document 247, 78th Congress, 2d Session, with a view to determining the feasibility and advisability of modifying the existing multiple-purpose dams to include provision of new facilities for navigation, including, but not limited to, locks, marine railroads, and boat elevators."

- Resolution adopted 8 March 1960. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on the Missouri River and Tributaries, published as House Document numbered 238, 73rd Congress, and other pertinent reports, with a view to determining whether any modification of the existing project is advisable at this time, with particular reference to construction of additional storage projects in the basin above Fort Peck for the purpose of flood control, hydroelectric power development, conservation, recreation, fish and wildlife propagation, pollution abatement, and other related uses."

- Resolution adopted 7 August 1962. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act of 1902, be, and is hereby, requested to review the reports on the Missouri River and Tributaries, published as House Document numbered 238, 73rd Congress, and other pertinent reports, with a view to determining whether any modification of the recommendations contained therein is advisable at this time, with particular reference to construction of additional storage projects on the Missouri River in the reach between the Garrison and Fort Peck Reservoirs for flood control, irrigation, navigation, hydroelectric power development, recreation, fish and wildlife, conservation, pollution abatement and other purposes, including related land resources."

- Resolution adopted 29 November 1966. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River Basin, published as House Document numbered 475, 78th Congress, and other pertinent reports, with a view to determining the advisability of modifying the authorized Oahe Dam and Reservoir, South Dakota and North Dakota, to provide subimpoundments within the reservoir area, in the interest of recreation, fish and wildlife preservation, sedimentation control, and other related water and land resources."

● Resolution adopted 3 February 1967. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River Basin, published as House Document numbered 475, 78th Congress, and other pertinent reports, with a view to determining the advisability of modifying the authorized Fort Randall Dam and Lake Francis Case, South Dakota, to provide subimpoundments within the reservoir area, in the interest of recreation, fish and wildlife preservation, sedimentation control, and other related water and land resources."

● Resolution adopted 25 November 1969. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River Basin, published as House Document numbered 475, 78th Congress, and other pertinent reports, with a view to determining the advisability of providing additional hydro-power at the main stem reservoirs."

● Resolution adopted 2 June 1970. "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Missouri River and Tributaries printed in House Document numbered

475, 78th Congress, and other pertinent reports with a view to determining whether any modifications of the recommendations contained therein are advisable at this time with particular reference to determining methods of resolving land use problems in the Buford-Trenton Irrigation District and Vicinity, resulting from a high water table."

- River and Harbor and Flood Control Act, approved 31 December 1970, Public Law 611, 91st Congress, 2d Session. "SEC. 226. The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to review and study the operation of the Fort Randall multiple-purpose project, South Dakota, with a view to determining the advisability of modifying the project facilities or the regulation of the impounded waters, or both, and report thereon to the Congress."

General Authorities

4. In addition to the specific study authorities, Congressional actions of a broader, general nature also impact on this investigation. These general authorities include:

- Section 122 of the 1970 River and Harbor and Flood Control Act (PL 91-611).
- Section 216 of the 1970 River and Harbor and Flood Control Act (PL 91-611).

Scope of Study

5. The studies have examined the feasibility of installing additional generating units at the existing main stem dams; the

opportunities and feasibility for new power developments adjacent to the Missouri River; bank erosion problems and potential alternatives for problem resolution; waterlogging and sedimentation problems and potential alternatives for problem resolution; recreation, fish and wildlife enhancement opportunities including legal and institutional requirements for implementation; main stem system operating plans in light of possible future water uses; and an update of navigation potential upstream from Sioux City, Iowa. Studies were extensive enough to permit plan selection, to determine economic feasibility, and, with one exception, to respond fully to the study authorities. Because of deferred plan elements, the selected plan provides an interim response to the 1969 Senate Public Works Committee resolution in regard to additional hydro-power.

Study Participants and Coordination

6. The Corps of Engineers had the principal responsibility for conducting and coordinating the study, plan formulation, consolidation of other agency information and preparing the report, except for evaluation of the reach below Gavins Point for possible designation as a component of the National Wild and Scenic Rivers System (PL 90-542). Responsibility for this study was shared jointly with the Bureau of Outdoor Recreation.

7. Coordination with the following agencies was a part of the study effort.

Missouri River Basin Commission
Bureau of Reclamation
Fish and Wildlife Service

Bureau of Outdoor Recreation
Soil Conservation Service
Federal Power Commission
Environmental Protection Agency
National Park Service
U. S. Geological Survey
Bureau of Indian Affairs
Bureau of Land Management
Nebraska Game and Parks Commission
S. D. Dept. of Game, Fish & Parks
N. D. State Game & Fish Department
Montana Dept. of Fish and Game
S. D. Dept. of Natural Resource Development
North Dakota State Water Commission
Montana Dept. of Natural Res. & Conservation

8. The Bureau of Reclamation and the Federal Power Commission provided information on electric power transmission costs and requirements and capacity and energy costs and benefits, and the certification of needs for generating capacity. The Fish and Wildlife Service together with counterpart offices in the four states analyzed the probable effects on fish and wildlife resources. Land use information was received from County Agents in Montana, North Dakota, Nebraska, and South Dakota.

9. Appropriate State Planning agencies served as information clearinghouses during the course of the study.

10. Public meetings have been held at various times concerning the six separate survey investigations the most recent of which concerned the initiation of the additional hydro-power study in 1971. After consolidation of the six surveys into a single Umbrella Study, public meetings were held at Bismarck, North Dakota, Great Falls, Montana, Pierre and Yankton, South Dakota, 28, 29, 30 June and

1 July 1976, respectively. In addition, two interim status reports were widely distributed to the public.

The Report

11. This report has been arranged into a main report with three appendices. The main report is a non-technical presentation of the feasibility study. It contains a description of the study area, including existing improvements; current problems and opportunities; formulation of a suitable plan; a summary of economic benefits, costs, and justification; a designation of appropriate responsibilities between Federal and non-Federal interests; and recommendations for implementing the selected plan. Appendix 1 is a technical report following the same general outline written in greater detail for the technical reviewer. Problems and their possible solutions are presented in the same order as found in the main report. Appendix 2 contains all pertinent correspondence. Appendix 3 contains reports from other agencies.

Prior Studies and Reports

12. Prior reports by the Corps of Engineers covering the reach of

the Missouri River under consideration in this investigation date back to 1881. Table A-1 lists them and summarizes their conclusions.

Table A-1 PRIOR REPORTS BY CORPS OF ENGINEERS ON THE MISSOURI RIVER

Report	Date	Type	Remarks
H. Ex. Doc. 92, 46th Cong., 3d Sess.	Febr. 1881	Preliminary report on navigation on the Missouri River.	No specific conclusions or recommendations on Missouri River above Sioux City, Iowa
H. Doc. 91, 62d Cong., 1st Sess.	Dec. 1910	Report on 6-foot navigation channel, Missouri River, Sioux City to Williston, North Dakota.	Generally unfavorable to improvement, but snagging, rock removal, and limited stabilization works recommended.
H. Doc. 594, 69th Cong., 2d Sess.	Oct. 1926	Preliminary examination report, Missouri River, Kansas City, Kansas, to Pierre, South Dakota.	Channel improvements above Sioux City not justified.
H. Doc. 238, 73d Cong., 2d Sess.	Mar. 1933	The 308 report on examination and survey of Missouri River.	Recommended completion of navigation project below Sioux City and construction of Fort Peck Dam and Reservoir.
H. Doc. 214, 76th Cong., 1st Sess.	Dec. 1938	Re-examination report on navigation channel, Missouri River, Sioux City to mouth.	Recommended 9-foot channel in lieu of 6-foot channel. Subsequently authorized by River and Harbor Act of 1945.
H. Doc. 821, 76th Cong., 3d Sess.	Apr. 1940	Re-examination report with respect to flood control on Missouri River, Sioux City, Iowa to Kansas City, Missouri.	Recommended flood control project for protection of riparian lands against erosion between Kenslers Bend, Nebraska and Sioux City, Iowa.
H. Doc. 475, 78th Cong., 2d Sess.	Dec. 1943	Review report on flood control on Missouri River from Sioux City to the mouth.	Recommended construction of 3 multiple-purpose dams on Missouri River above Sioux City, Iowa.
Investigation of Bank Erosion on Missouri River at Buford-Trenton Irrig. Project, North Dakota.	Dec. 1951	Reconnaissance report on bank erosion near pump intakes U/S from mouth of Yellowstone on Missouri River left bank.	Recommended emergency funds of $30,000 be allocated under Sec. 14 of 1946 FCA to construct measures to protect Buford-Trenton pumping plant.
Protective Works in the Williston Area of the Garrison Reservoir	Dec. 1953	Responded to Senate Report on FY 1954 Appropriation Bill for protection to Williston, N.D., Lewis & Clark Irrig. Dist., & East Bottom of Buford-Trenton Irrigation District.	Presented a plan of protective works due to Lake Sakakawea impacts & due to sediment deposits in upper end of the Lake. PL 84-163 provided funds for purchase in lieu of protection, of Lewis & Clark Irrigation District and East Bottom. The Act was modified by PL 84-641 & PL 85-38 & East Bottom was purchased in 1958.
Review Report on Bank Stabilization Buford-Trenton Irrig. Dist., Missouri River, N.D.	Aug. 1961	Responded to 28 Jan. 55 resolution for determining methods of preventing land loss in Buford-Trenton Irr. Dist. from bank erosion.	Negative report since PL 85-58 in 1957 authorized purchase of East Bottom & for protection of intake structure of Buford-Trenton pumping plant & for bank protection works adjacent to Dist. Protective works completed in 1961.

Table A-1 PRIOR REPORTS BY CORPS OF ENGINEERS ON THE MISSOURI RIVER (CONT'D)

Report	Date	Type	Remarks
Garrison Dam to Oahe Dam Bank Erosion Study	1961-1962	Response to 20 April 1959 Public Works resolution for determining measures for reducing bank erosion problems.	In 1962, State of North Dakota requested deferral of study, subsequently isolated 5 high value areas in need of protection. Direct authorization of protective works by PL 88-253 on 30 Dec. 1963 and works constructed.
Missouri River, Ft. Peck Reservoir to Vicinity of Ft. Benton, Mont.	Jun. 1963	Joint Survey by Army & Interior on Missouri River power potential above Fort Peck, Montana.	Recommended High Cow Creek & Ft. Benton projects of 1020 mw to meet power demands. Plan not supported by Montana. No action taken on report.
Review Report, Missouri River, N.D., S.D., and NE.	Apr. 1965	Survey report on navigation & bank stabilization from Montana-North Dakota Stateline to Sioux City, IA.	Recommended extension of navigation U/S to Gavins Pt. Dam & Bank protection works in same reach. Sec'y. of Army returned report in Apr. 1969.
Supplemental Report, Bank Erosion Problems, Gavins Point Dam - Sioux City, Iowa	Mar. 1972	Supplement to 1965 report prepared by joint task force of Nebraska, South Dakota, Universities, landowners, and BSF&W and C of E on bank erosion measures.	Concluded best alternative would be selected land acquisition and bank protection measures in combination. Plan included in River & Harbors Bill in 1972 but vetoed by President Nixon.
Modification of Operation of Lake Francis Case, South Dakota	Oct. 1972	Response to Sec. 226 FCA 1970 to limit drawdown at Ft. Randall to reduce adverse environmental & aesthetic effects from normal 30-ft. drawdown.	The Coordinating Committee adopted a compromise operation limiting drawdown to 12.3 ft. except during droughts.

SECTION B

THE STUDY AREA

THE STUDY AREA

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SECTION B

THE STUDY AREA

1. Focus of this study is the narrow belt bounding the open-water river reaches and impoundments, from the junction of the Jefferson, Madison, and Gallatin Rivers in southwest Montana where the Missouri River is formed downstream to Sioux City, Iowa. For analyzing problems and opportunities associated with water and related land resources those counties immediately adjacent to the River (and impoundments) are identified as corridor counties, counties being the smallest political unit for the compilation of present-day demographic, social, cultural and economic data. In analyzing future trends these data are presented for larger aggregations of counties. Water Resources Subareas, as designated by the U. S. Water Resources Council, are the smallest unit for which projections have been made. Twelve of the 16 Water Resources Subareas in that portion of the Missouri River Basin above Sioux City contain one or more corridor counties. Therefore, much of the following discussion of the study area (corridor counties) will touch on how this smaller area relates to the larger drainage basin.

Geography and Geology

2. Although the area of this study is rather sharply confined to river and adjacent valley lands, some aspects must treat the full breadth of those "corridor" counties immediately adjacent to the river while others, to be meaningful must address the entire drainage area of the basin.

Locale

3. The Missouri River Basin, bounded by the northern and central Rockies on the west, the Arkansas River Basin on the south, and the Mississippi River and Red River of the North on the east, also drains the southern portions of Alberta and Saskatchewan in Canada. The total drainage area is estimated to be 529,350 square miles (338, 784,000 acres) with less than two percent in Canada. The remaining 519,635 square mile area represents about 17.1 percent of the conterminous United States. The area above Sioux City, is almost 301,470 square miles, or about 57 percent of the Missouri River Basin. The corridor counties represent about 17 percent of the Missouri River Basin. The Basin and the portion included in this study are shown on Plate B-1.

Table B-1 LAND AREA IN THE CORRIDOR COUNTIES AND THE UPPER MISSOURI BASIN AREA*
(Square Miles)

Political Subdivisions	Corridor Counties	Noncorridor Counties	Total Area
Montana	48,010(15)	72,420(31)	120,430
North Dakota	18,590(11)	21,110(18)	39,700
South Dakota	18,180(18)	55,980(47)	74,160
Nebraska	2,860(4)	18,340(9)	21,200
Rest of Area 1/	---	45,980	45,980
Total	**87,640**	213,830	301,470

1/ Iowa 1,350 square miles; Minnesota 1,660 square miles and Wyoming 42,960 square miles.

(xx) Number of counties

Source: U. S. Department of Commerce, Bureau of Census

* **Within Upper Missouri River Subareas**

Physical Description

4. The Missouri River Basin drainage area above Sioux City is mostly within the Interior Plains physiographic division. Some upstream tributaries originate in western Montana and northwestern Wyoming in the Northern and Middle Rocky Mountain provinces of the Rocky Mountain System division. Elevations range from over 14,000 feet above mean sea level (M.S.L.) to about 1,080 at Sioux City, Iowa. In the mountainous area local glaciation provides interruptions in the form of broad valleys. In south central Montana and Wyoming mountain ranges such as the Big Horns reach into the adjacent plains and plateaus. Occasionally an isolated mountain range appears, such as the Black Hills in western South Dakota and eastern Wyoming. In the area perimeter to the mountains minor tributaries have steep gradients and channels are "V"-shaped through canyons.

5. The Interior Plains Division includes the Great Plains and Central Lowlands provinces, the latter occupying the James and Big Sioux river basins in eastern North and South Dakota with relatively flat to rolling topography. Old glacial Lake Dakota is occupied by the central portion of the James River valley. Many small glacial lakes are found in northeastern South Dakota. The Sioux Falls uplift, quartzite, is prominent in southeastern South Dakota. Most of the Great Plains occupy elevations from 2,000 to 3,000 feet. In central and eastern Montana and western North and South Dakota, south of the Missouri and Teton rivers is the unglaciated Missouri Plateau. This is rugged country of eroded river valleys with "badlands" type topography and isolated buttes on extensive plateaus. To the north and east is the glaciated Missouri Plateau with morainal hills. Along the Niobrara drainage in the south, the topography varies from the Pine Ridge escarpment to the northern edge of the Sand Hills of Nebraska.

6. The Missouri River is formed in southwestern Montana by the junction of the Jefferson, Madison, and Gallatin Rivers, each of which heads in the high mountain area in or near Yellowstone National Park. From its point of formation to the "Gates to the Mountains," a point named by Lewis and Clark and located about 30 miles upstream from Great Falls, the river flows generally north through steep narrow canyons broken by short reaches of relatively wide valleys. The average fall of the river in this reach is about six feet per mile and its tributaries are generally short and steep. In this reach, the river flows adjacent to the Helena National Forest and through the Canyon Ferry Reservoir, a Bureau of Reclamation project for power, irrigation, and flood control. It also flows through the smaller reservoirs formed by the Hauser and Holter dams, both power projects.

7. Upstream of Great Falls, in the transition area between the Rocky Mountains and the Great Plains, the Missouri River changes

character. It emerges from its canyon and enters into a relatively wide foothill valley that gradually merges into the plains area. Below Great Falls, the river lies in a narrow meandering valley surrounded by high benches and prairies. The Sun River, from the west, is the principal tributary.

8. The Missouri River between Morony Dam and Fort Peck Reservoir is 200 miles long, has a fall of 550 feet, and slopes three feet per mile. The Teton and Marias Rivers from the north and the Judith River from the south are the principal tributaries in this reach. In addition, the Musselshell River flows from the south into Fort Peck Reservoir. The river bottomland, 500 to 1,000 feet below the average elevation of the adjacent upland, is comparatively narrow and essentially undeveloped. In the entire reach, only about 5,500 acres of flood plain land are cultivated. Tributary drainage and geological erosion have produced highly dissected, rough terrain, resulting in spectacular, varied and highly scenic badlands and breaks area ranging from two to 10 miles in width adjacent to both sides of the valley.

9. In the 190-mile reach between Fort Peck Dam and the headwaters of Lake Sakakawea near the Montana-North Dakota state line, the Missouri River drops about 180 feet in elevation. Here the valley varies from one to four miles wide, averaging about two miles, and is 200 to 700 feet below the upland area. The major tributaries are the Milk River from the north just downstream of Fort Peck Dam and the Yellowstone River from the south just upstream of Lake Sakakawea. Main stem flows are well controlled by Fort Peck. Although the problem is less critical than in other reaches, some bank erosion and shoaling occur.

10. From the headwaters of Lake Sakakawea to Gavins Point Dam, a distance of 757 miles, the main stem reservoirs occupy more than 620 miles of the river valley. Open reaches of river exist between Garrison and Lake Oahe (87 miles), between Oahe and Lake Sharpe

(5 miles), and between Fort Randall and Lewis and Clark Lake (43 miles).

11. From Gavins Point Dam to Ponca, NE., a distance of about 59 miles, the Missouri River is still in a semi-wild state. River discharges are regulated by the Gavins Point project and significant flooding has been eliminated. Except for isolated reaches, banks have not been stabilized and the river is free to meander over wide limits. Bank erosion is continually active. The river has a slope of about 1 foot per mile and the channel is from 1,200 feet to 5,000 feet wide, averaging 2,600 feet. Below Ponca, the river has been stabilized 18 miles by the Sioux City to Kenslers Bend project; upstream, the area between high banks has multiple channels, low islands, sand bars, and bordering marsh with extensive willow growth. Some areas along the river bank are cultivated, while in others native timber growth extends a short distance inland from the bank. The major tributaries are the James, Vermillion, and Big Sioux rivers.

Flow Regimen

12. Wide variances in seasonal flow characterize the Missouri River. The winter season is a period of low flows. From December to February, ice may cover the river as far south as Kansas City, Missouri. A typical spring rise begins in late March or early April with the melting of plains snow cover. A rise which is generally lower in peak flow but greater in volume is usually experienced in June when snowmelt from the higher plateaus and mountains may combine with runoff from prolonged spring rainfall. This is the usual period of maximum flow in the upper basin tributaries which are fed primarily by mountain snowmelt.

13. Following the June rise, low flows usually prevail during the late summer and early autumn, interrupted by rises caused by occasional heavy rains.

14. Annual runoff, like seasonal flow, fluctuates widely. At Sioux City the yield has ranged from 37 million acre-feet in 1927 to 10.6 million acre-feet in 1931. Since the first year of annual flow tabulation, 1898, the upper basin has experienced two protracted droughts. The first, extending from 1930 through 1941, averaged 15.6 million acre-feet per year at Sioux City. The second, running from 1954 through 1961 averaged 18.3 million acre-feet annually. These values are deficient by one-third and one-fourth, respectively, compared to the long-term average of 24.7 million acre-feet.

15. In its natural state the Missouri River transported a sediment load increasing from an average of 25 million tons per year in the vicinity of Fort Peck to 150 million tons per year at Yankton, South Dakota. Since construction of the main stem dams, beginning with the closure of Fort Peck in 1936, sediment entering the reservoirs has been trapped, with a consequent change in the historic formation of accretion lands which formerly offset erosion effects.

16. The historic flood, by which all others in the upper basin are judged, occurred in 1881. A heavy snow blanketed the plains area that spring. Huge ice gorges in the Dakotas accompanied the spring thaw and the ice breakup. A crest of 18.5 feet above flood stage was reached at Yankton, South Dakota, highest known on the Missouri River. The flood produced a volume estimated to be over 40 million acre-feet at Sioux City, Iowa.

17. A flood in April 1952 on the Missouri River and most of its tributary streams was of exceptional magnitude, again created by heavy snow melt and compounded by ice jams. The flood flow was 500,000 cubic feet per second (cfs) at Bismarck, North Dakota and 480,000 cfs at Yankton, South Dakota. Stages set by the 1881 flood, however, were not surpassed.

18. Runoff in 1975 from the drainage area controlled by the main

stem reservoir system (i.e., upstream of Gavins Point Dam) exceeded any previous year in a record extending back to 1898, although downstream at Sioux City the annual volume in 1927 was one million acre-feet greater. On 1 March 1975 inflow to the main stem system was slightly below normal, with the prospect that this trend would prevail for the remainder of the year. However, beginning in April, there was a dramatic increase in runoff, particularly in Montana and North Dakota, where late season snowfall in the mountains and widespread torrential rains occurred. Runoff for the May, June, July period in 1975 was 20.6 million acre-feet compared to the previous maximum of 18.9 and an average of 11.3.

19. Regulation of this inflow resulted in new storage records at Fort Peck, Garrison and Oahe and record release rates ranging from 35,000 at Fort Peck in the upper end of the system to 61,000 at Gavins Point at the downstream end. Flooding associated with these releases was minor with the exception of a 10-mile reach upstream from the mouth of the Niobrara River - about which more will be reported in subsequent pages. During the flood season 12 million acre-feet of flood flows were stored with reduction in peak flow of about 110,000 cfs in all the downstream river reaches except for an 80,000 cfs reduction below Fort Peck.

Climate

20. Climatic types range from Humid Continental Long-Summer in southeastern South Dakota to Highland type in the mountainous area of western Montana. Humid Continental Short-Summer Climate is found in eastern North and South Dakota, eastern Montana, central and eastern Wyoming. Western North and South Dakota and adjacent Nebraska experience Middle Latitude Steppe Climate.

21. Extremes in temperature are induced by alternating cold air masses from the northwest and warm air masses from the gulf region. Seasonal and even daily temperature ranges are large. Except in

the mountains, temperatures sometimes exceed 100°F in the summer and fall below-zero during the winter months. Most of the year daily temperatures may vary from 30 to 40 degrees.

22. Generally winds are from the south in the summer and from the north and northwest in the winter. Maximum wind velocities range from 45 to over 100 miles per hour, while average monthly velocities range from seven to 13 miles per hour. Hot dry winds occurring during the spring and summer can cause crop damage and duststorms. Blizzards can occur in the winter in most parts of the basin. They menace human life, livestock, wildlife, private property, as well as public services and transportation systems.

23. The most critical climatic factor is precipitation, since the primary industry of the area is agriculture. The highest average annual precipitation occurs in the mountains, where amounts may total over 40 inches including 100 inches or more of snow. Spring and early summer snow melt and rainstorms fill the main stem reservoirs, providing water for irrigation, power, recreation, navigation, and other purposes. The Great Plains portion of the basin is noted for its relatively scanty and erratic precipitation. From the southeast to the northwest the average annual amounts range from about 25 inches to about 12 inches. Because most of the rainfall occurs in the plains between May and early July, productive agriculture is possible. Occasional high intensity thunderstorms, often with high winds and hail, cause severe crop damage. Winter snowfall in the plains is generally light. The Great Plains have low annual runoffs, generally less than one inch. In the eastern part of the basin, the Central Lowlands, seasonal precipitation is more evenly divided between winter snows and summer rains. Annual runoff generally is more than four inches. Storm rainfall is the primary cause of flooding.

Minerals

24. Exploitation of mineral deposits in the Missouri River basin above Sioux City has historically played an important role in the settlement and development of particular areas. Early settlement of the mountainous areas of western Montana and the Black Hills of South Dakota was stimulated by the discovery of gold and silver. Expanded production of lignite and coal began in the mid-1960's. Additional thermal generating plants coupled with the promised development of gasification facilities will command sizeable quantities of water resources in the coming decades. These most recent developments will likely have tremendous socio-economic impact on rural communities in the North Dakota - Montana - Wyoming crescent.

25. Metallic mineral deposits are associated with the mountainous areas of western and central Montana and the Black Hills of South Dakota and adjacent Wyoming. In addition to the early development of silver and gold, other base metals such as copper, lead, and zinc were exploited. More recently, ferroalloys and minor minerals, such as tungsten, vanadium, chromium, beryllium, lithium, and possibly most important uranium and thorium have been produced.

26. Virtually all counties in the region produce non-metallic minerals. Production is limited to sand, gravel and stone in the eastern part of the basin. These minerals together with gypsum and limestone found in other parts of the basin are closely associated with various parts of the construction industry. Fertilizer ingredients such as phosphate, and potash are found chiefly in Montana and Wyoming. Numerous minerals for chemical and other miscellaneous uses, such as fluorspar, feldspar, mica, salt and bentonite, are found primarily in the western portion of the basin.

27. As a group, mineral fuels represent the greatest mineral resource now in production in the basin. While past production has

been predominently oil and gas, future mineral fuel production will likely be dominated by coal resources. Oil and gas production has been primarily limited to the Montana, Wyoming and western North Dakota portion of the upper Missouri River basin. Bituminous coal areas are found in scattered sections of central Montana. Sub-bituminous coal deposits are in north central and south central portions of Montana and north central and northeastern Wyoming. The lignite coal area is more nearly continuous, covering most of eastern Montana and the western one-half of North Dakota with a relatively small amount found in adjacent northwestern South Dakota. An estimated 160 billion tons of recoverable coal or about 37 percent of the Nation's total known recoverable reserves are located in this area.

Soils and Vegetation

28. Native soils in the basin are related to zones of climate and vegetation. Most have developed under grass cover. The exception is the mountain complex soils of the Rockies, the Black Hills and adjacent areas where coniferous forests are the principal vegetation.

29. Brown soils are in the semi-arid short-grass plains of eastern Montana and adjacent Wyoming. Desert and sierozem (light-gray) soils occupy small areas in intermountain basins and high dry plateaus. Chestnut (light-brown) soils occur where mixed tall and short-grass is found in eastern Montana and Wyoming, western North and South Dakota, and adjacent parts of Nebraska. Chernozem (dark-brown) soils across eastern North and South Dakota and adjacent Nebraska developed under tall and mixed grasses. Brunizem (black) and some gray-brown podzolic soils occur in southeastern South Dakota, southwestern Minnesota, and adjacent parts of Iowa and Nebraska. Alluvial soils of bottomlands and terraces occur in all zonal groups.

Man and His Works

30. The Missouri River has played a key role in man's journeys and settlements across a heartland area making up a sixth of the 48 contiguous states. From prehistoric times until today, developing patterns of communications, population, and commerce have felt the river's influence.

Cultural Resources and History

31. The valley environment of a major stream such as the Missouri is richly diverse with a population of many kinds of plants and animals. Stone age hunters and gatherers were quick to exploit these riches which were much more important to their survival than to survival of men in a mechanized era. Throughout the 12,000 year chronology of known human occupation, the upper Missouri valley has provided the necessities of food, water, cover and fuel and with the convenience of a well landmarked trailway. Each of Paleo-Indian, Archaic and Late Prehistoric hunting and gathering culture knew and used these resources, although the degree varied among cultures.

32. Physical evidence left behind by these early peoples furnishes clues to their ways of life. An accumulation of such clues is termed a "site" by archaeologists. For the reasons mentioned above, the length of the Missouri trench abounds in such sites, representing the ways of life of many different peoples across 12,000 years of time and 1,600 miles of linear space.

33. By far, the best known and best understood of these are the Plains Village Tradition sites. Once occupied by ancestors of the present-day Mandan, Hidatsa, and Arikara tribes who may have settled the villages as early as the 10th Century, A.D. these sites extend roughly from the upper half of Lake Francis Case to above Lake Sakakawea. There are two major reasons for this knowledge: the relative visibility and impressiveness of these sites compared to sites

briefly occupied by nomads, i.e., hunters such as the plains tribes who lived to the west of the Missouri, and the relative degree of study enabled by archaeological salvage programs connected with main stem reservoir construction. A great deal of study is still needed, but at least workable basic chronology and taxonomy now exist upon which to base further research.

34. A vast amount of useful data regarding the Plains Village Tradition and the earlier inhabitants has been lost through inundation and lakeshore erosion. Limitations on time and funding allowed identification and recovery of only a fraction of the prehistoric data affected by construction of the main stem reservoir system. The relative scientific and historical value of those sites and portions of sites still remaining is thus increased many-fold.

35. As a landmark, a concentration of useful resources, and a useable -- if hazardous -- water highway, the Missouri drew the earliest European explorers to its length. French traders and explorers from Louisiana and from Canada were acquainted with portions of the Missouri almost 70 years prior to the Louisiana Purchase in 1803. After the Lewis and Clark Expedition of 1804-06, American entrepreneurs quickly expanded the quest for furs and trade up the Missouri River. By the time the first steamboat entered the Missouri River (1819), keelboats and American traders were familiar visitors on the Upper Missouri nearly every summer. In 1859 the steamer "Chippewa" successfully ascended the river as far as Fort Benton. Marked cultural change in Indian life was accelerated by these contacts with Europeans.

36. Government-backed explorations and military expeditions continued through the first three-quarters of the 19th century. At Bannack, Montana, a rich gold strike was made in 1862. Subsequent gold discoveries at Virginia City and Helena brought thousands of prospectors. General Custer's expedition to the Black Hills of

South Dakota in 1874 and the attendant discovery of gold brought the Black Hills Gold Rush of 1875-77. Homestake Gold Mine near Lead remains the largest gold mine in the Nation.

37. After the Civil War, large cattle outfits began trailing herds northward from Texas into the Great Plains. Expansion of white man into the Indians' homeland, his subsequent destruction of the buffalo, and his concept of "Manifest Destiny" brought the Indian wars of the 1860's and 1870's, and the conquest of the plains which was essentially complete by 1878.

38. While statehood came to Iowa in 1846 and Minnesota in 1858, most of the balance of the area west of the Missouri River lacked definition until the Kansas-Nebraska Act of 1854 established the Nebraska Territory. From this Act, the Dakota Territory, including what today are the two Dakotas and parts of Montana and Wyoming, came into being in 1861. Nebraska became a state in 1867, Montana and the two Dakotas in 1889, followed by Wyoming in 1890.

39. Many sites representing the period between the Louisiana Purchase and the close of the 19th century have been destroyed by subsequent acts of man. Their loss, like the loss of prehistoric sites discussed earlier, adds to the importance of surviving remnants. General awareness of this fact has resulted in the increasing emphasis being given to historic and archaeological resources where water resources might impact. Congressional interest is expressed by Public Law 93-291 - Preservation of Historical and Archaeological Data - wherein up to one percent of project funds may be expended on survey and preservation activities.

40. Settlement was greatly enhanced by two events, passage of the Homestead Act of 1862 and extension of railroads. The Homestead Act provided title for up to 160 acres of land for a nominal fee to any citizen of good character who would agree to live on the land and

develop it for five years. Later acts and amendments did permit limited claims of up to 640 acres by one person. Farms of 160 acres or less were adequate where precipitation was sufficient. Frequent droughts, a relatively short growing season, low annual precipitation, increasing mechanization and capital requirements gradually pushed the 160-acre farm into the southeastern part of the study area, where today the average size farm is 275 acres or more.

41. Railroads entered eastern Dakota in the 1870's. Most major lines east of the Missouri River were operating by the late 1880's: the Northern Pacific reached Bismarck, North Dakota in 1873 and the transcontinental connection through Montana was completed in 1883. This was followed by the Great Northern Railway. While railroads entered the Black Hills in western South Dakota from Nebraska in 1885, it was not until 1907 that railroads crossed the Missouri River and western South Dakota. A major impetus was large Federal land grants which railroad companies were anxious to sell for construction capital. Mining and forested areas in the western portion of the basin offered traffic potential as did the growing need to move agricultural products.

42. The uncertainty of harvesting a crop in the Great Plains motivated a more comprehensive approach to the management of water and related land resources in the basin. One of the first major multiple-purpose water resource development projects authorized by Congress in 1933 was the Fort Peck Dam and Reservoir. Investigation and construction of Great Plains projects were authorized under the Wheeler-Case Projects Act of 1933 and the Water Conservation and Utilization Act of 1939. With the Interior and Agricultural departments operating together on small projects, the Bureau of Reclamation and Corps of Engineers began planning for full-scale development of water resources in the Missouri River Basin, which culminated in a single plan approved by Congress in Section 9 of the Flood Control Act of December 22, 1944, known as the "Pick-Sloan Plan." The

plan, with later modifications, provided for the construction of 316 separate project units, with 112 dams containing a total storage capacity of 107 million acre-feet, 4.3 million acres of irrigation, 2.6 million kilowatts of hydroelectric generating capacity, and a nine-foot navigation channel on the Missouri River below Sioux City. Also recognized were potentials for recreation and water supply for municipal and industrial purposes. Some of the plan elements are yet to be completed.

Population

43. While the national population expanded about 35 percent between 1950 and 1970 and the Missouri River Basin population increased at a slightly lesser rate, 21 percent, the Upper Missouri River area remained rather stable, increasing less than four percent (from 1,615,000 in 1950 to 1,674,000 in 1970) as shown in **Table B-2.** During 1950-60, the Upper Basin displayed modest growth, but declined during the following decade. The corridor counties displayed similar growth patterns except for Montana which experienced growth in both decades.

44. The trend locally and nationally has been toward greater urban populations. The Upper Basin area lagged the Missouri River Basin and the Nation in this characteristic because of the predominance of agriculture in the region. The corridor counties in Montana and North Dakota exhibit a slightly higher percent of urban population, due primarily to the Great Falls Standard Metropolitan Statistical Area (SMSA) and the North Dakota cities of Williston and Bismarck-Mandan.

45. All or parts of 24 Indian Reservations are located in the Missouri River Basin. Seventeen, plus part of the Sisseton-Wahpeton Reservation, are in the Upper Missouri River Basin area as shown in Table B-3. Nearly 90 percent of the Missouri River Basin Indian population of 62,428 in 1973, lived on or near reservations in the Upper

Basin area. Of these, almost 50 percent reside in nine of the above referenced reservations on or near the Missouri River above Sioux City.

Table B-2 - POPULATION DISTRIBUTION*
1950-1970

Area		Total Population	Corridor Counties Only	Urban	Rural Nonfarm	Farm
		(1,000's)			(Percent)	
Upper Missouri River Basin (1)	1950	1,615	478	32 (30)	31 (33)	37 (37)
	1960	1,719	518			
	1970	1,674	507	45 (45)	32 (33)	23 (22)
Montana	1950	405	178	41 (48)	32 (29)	27 (23)
	1960	474	214			
	1970	472	220	55 (60)	30 (28)	15 (12)
North Dakota	1950	265	129	19 (26)	36 (33)	45 (41)
	1960	266	136			
	1970	245	130	35 (44)	35 (32)	30 (24)
South Dakota	1950	628	128	34 (18)	28 (38)	38 (44)
	1960	657	129			
	1970	645	122	45 (31)	31 (40)	24 (29)
Nebraska	1950	111	43	22 (0)	34 (41)	44 (59)
	1960	103	39			
	1970	92	35	30 (0)	42 (52)	28 (48)
Missouri River Basin	1950	7,063		49	23	28
	1960	7,931		57	24	19
	1970	8,550		64	22	14
United States	1950	151,300		64	21	15
	1960	180,700		66	26	8
	1970	204,900		73	22	5

(1) Includes portions of Iowa, Minnesota and Wyoming
(XX) Percent in Corridor counties
Source: U. S. Department of Commerce, Bureau of Census
* Within Upper Missouri River Subareas

Table B-3 - INDIAN POPULATION - 1973
UPPER MISSOURI RIVER BASIN

Reservation or Location	Total 1/	Female	On Reservation
		(Percent)	
Montana			
FORT PECK 2/	6,202	48.9	86.6
Other (Blackfeet, Crow, Ft. Belknap, Northern Cheyenne, Rocky Boy's)	16,775	50.1	92.4
North Dakota			
FORT BERTHOLD	2,775	51.3	93.7
STANDING ROCK 3/	2,726	48.8	95.3
South Dakota 4/			
CHEYENNE RIVER	4,335	51.2	97.2
CROW CREEK	1,242	57.4	97.9
LOWER BRULE	702	52.3	96.2
ROSEBUD	7,538	50.4	98.6
STANDING ROCK 3/	2,142	48.7	95.3
YANKTON	1,425	49.5	86.1
Other (Flandreau, Pine Ridge)	11,761	50.0	75.6
Nebraska			
SANTEE	357	51.5	71.7
Wyoming			
Wind River	4,538	52.5	85.6

1/ March 1973 Labor Force Report. 2/ Reservations in CAPS on Missouri River. 3/ Part in ND & SD. 4/ Not including Sisseton-Wahpeton Res. Source: U.S. Dept. of Interior, Bur. of Indian Affairs.

Communications

46. Both cultural and business communities of the Upper Basin are served by modern communication networks. Because of the large geographic size and relatively low population density, a slightly higher ratio of media outlets, (newspapers, radio and television stations) exists per capita than most sections of the Nation. The Earth Resources Observation Systems (EROS) Center is located near Sioux Falls, South Dakota.

Transportation

47. Facilities and services associated with transportation in the upper portion of the Missouri River basin are parts of the greater national network. They serve the economic and social demands of people residing within the area. Each of the various modes - airlines, highways, pipelines, railroads - play an important role in development of the region.

48. The air transportation network is a mixture of trunk routes serving the major cities and feeder lines tying in the lesser communities. Trunk line service is oriented generally on an east-west basis, serving the Twin Cities, Denver, and west coast cities. In the western portion of the basin, trunk lines follow a north-south orientation, flowing from Great Falls to Denver. As displayed in Table B-4, the regional feeder service provides traffic movement both east-west and north-south to trunk lines within the area. Because of the relatively great distances between communities within the area and elsewhere, the service provided by airlines has been particularly valued.

Table B-4 - TRANSPORTATION NETWORK
SELECTED CITIES

	Airlines	Highways	Pipelines	Railroads
Montana				
Billings	T	I	C,P,N	M
Bozeman *	T	I	P,N	X
Glasgow *	X	X	N	M
Glendive	X	I	C,P,N	M
Great Falls *	T	I	C,N	X
Havre	X	X	N	M
Helena *	T	I	P	X
Lewistown	X	X		X
Miles City	X	I	P,N	M
Wolf Point *	X	X	C,N	M
Nebraska				
Alliance	X	X	N	X
Chadron	X	X	N	X
North Dakota				
Bismarck *	T	I	C,N	M
Dickinson		I	N	M
Jamestown	T	I		M
Williston *	X	X	C,N	M
South Dakota				
Aberdeen	X	X	N	M
Brookings	X	I	N	X
Huron	X	X	N,P	X
Mitchell	X	I	N,P	X
Pierre *	T	X		X
Rapid City	T	I	P,N	X
Sioux Falls	T	I	P,N	X
Watertown	X	I	P,N	X
Yankton *	X	X	P,N	X
Wyoming				
Cody	X	X	C,P	X
Lander	X	X	C,N	X
Sheridan	T	I	N,P	X
Worland	X	X	C,N	X

* Communities located in Corridor Counties
T= **Trunk Airline Routes, X = Other**
I= Interstate Highway System, X = Other
M= Transcontinental Mainline Railroad, X = Other
Pipelines: C=Crude, N=Natural Gas, P=Petroleum Products

49. Along with air transportation, the highway system has experienced expansion and upgrading. Through the central portion of the area most of the road network and all of the interstate highway system is east-west. In the southeast portion of the multi-state area and the western portion a north-south orientation of interstate and other highways is more prevalent. The role of the truck is particularly important in the collection and movement of agricultural products, complementing rail traffic for the long distant movement of bulk commodities. Use of the interstate system has expanded, significantly improving the efficiency of long distance truck movement. The modern highway system has also played an important part in the movement of tourist traffic to and through the area.

50. Perhaps the most economical and dependable form of transportation is the pipeline. Commodities transported by pipeline in the area include crude petroleum, petroleum products, and natural gas. Most of the directional orientation of pipelines is north-south, except in western North Dakota and most of Montana. Central South Dakota, from Rapid City east to the James River valley, has no pipeline service, nor does the James River basin west to Bismarck in North Dakota. The crude lines extend from production areas in western North Dakota, Montana, and Wyoming to refineries located near production or in principal market areas. A few petroleum product lines extend into eastern South Dakota, across Montana into northwestern North Dakota, and from Wyoming into southern Montana.

51. The system of railroad routes was developed for the most part during the settlement period of the late 19th century, hence the general orientation on an east-west basis, except in the easternmost portion of the Dakotas. The industry has undergone a transition from the major and almost sole carrier of goods and people to become predominantly a carrier of bulk commodities. Most of the major market areas in Montana, North Dakota, and northeastern South Dakota,

are served by branch and interconnecting routes. Some growth in traffic has been experienced and will likely continue to expand with the increased utilization of low-sulfur coals and lignite found in the area.

52. Waterborne traffic is of less significance to this area of the Missouri River basin, since the navigable portion of the River extends only to Sioux City, Iowa, the southeastern corner of the study area. The main stem dams are, however, very important to the operation of the navigable channel in the lower portion of the basin through the regulation of flows.

Land Use

53. Approximate measures of land area are provided in the Census of Agriculture shown in **Table B-5.** Changes in land areas from one enumeration year to another can result from changes in political boundaries, streams, lakes or construction of reservoirs. Changes in corridor counties noted between 1949 and 1959 for North Dakota resulted from filling of Lake Sakakawea above Garrison Dam; for South Dakota and Nebraska from filling of Lewis and Clark and Francis Case lakes behind Gavins Point and Fort Randall dams. Losses in land area among the corridor counties in the later decade are largely due to the filling of Lake Oahe in North Dakota and South Dakota and Lake Sharpe behind Big Bend Dam in South Dakota. Somewhat minor losses were also reported in the corridor counties due to erosion in open-river reaches of the Missouri River. During the period of observation, corridor counties in North Dakota experienced a loss of about 400,000 acres and South Dakota about 300,000 acres of land. At the same time there were some relatively large losses of land area in non-corridor counties, such as Tiber Dam and reservoir in Toole and Liberty counties, Montana.

AGRICULTURAL LANDS

54. While there was less total land area over time, the amount of land in farms was relatively stable. The reason only seven to eight acres out of ten are in farms in Montana can be ascribed to the mountainous terrain and the amount of land in public ownership. The public forest land is often leased for grazing, contributing to agricultural productivity while classified as public lands.

55. During the period cited farm numbers have declined significantly while the size of Montana farms has increased in size by about 50 percent in the corridor counties; North Dakota's about 44 percent; South Dakota's about 40 percent; and Nebraska's about 38 percent.

CROPPING PATTERNS

56. The amount of cropland harvested is always somewhat less than planted due to insufficient precipitation or other crop hazards. Moreover, during the three decades analyzed, North and South Dakota and Nebraska lost acreages in the corridor counties due to the main stem projects.

57. As shown by Table B-6, wheat is the largest single crop acreage in the upper part of the study area, with small grains and hay tied for second place. Moving south the importance of wheat steadily declines while hay and corn increase. No pronounced trends over time are evident except the conversion of Montana and North Dakota acres from wheat to small grain. The dollar values of crops, and livestock and poultry during the period are shown on Table B-7.

INDIAN LAND OWNERSHIP AND USE

58. About 10.3 million acres of land - 6.2 percent of the Upper Basin - are lands in trust ownership or available for use and benefit of Indians, according to statistical data made available by the Bureau of Indian Affairs (U.S.D.I.), dated 1973 displayed in Table B-8. Nine of the 17 reservations in the area border on the main stem of the Missouri River and these lands contain nearly 48 percent of the total Indian lands in the area. Several of the reservation areas and associated Indian lands were affected by taking of lands (about 330,000 acres) for main stem dam construction, principally Fort Berthold, Cheyenne River, Crow Creek, Lower Brule, Yankton, Rosebud and Standing Rock reservations. Although the tribes and individuals were compensated for the lands taken and assisted in resettlement, they felt the bottomlands taken represented their best land not only as an

Table B-6 - CROPLAND HARVESTED*

		Montana		North Dakota		South Dakota		Nebraska	
Harvested Cropland (1,000's of acres)	1949	7,136	(2,925)	9,731	(4,131)	16,776	(4,349)	3,625	(1,051)
	1959	7,697	(3,146)	9,334	(3,792)	10,079	(3,474)	3,225	(957)
	1969	7,528	(3,124)	7,987	(3,269)	12,034	(3,103)	2,493	(735)

Cropping Pattern in Percent for Harvested Cropland Acres

		Montana		North Dakota		South Dakota		Nebraska	
Corn-Grain	1949	0.1	(-)	1.7	(1.6)	18.7	(19.5)	20.6	(48.9)
	1959	-	(-)	0.5	(0.2)	23.5	(18.6)	18.6	(47.4)
	1969	-	(-)	0.3	(0.3)	17.9	(17.2)	17.7	(40.4)
Corn-Silage	1949	0.2	(0.4)	0.8	(0.6)	0.7	(0.3)	0.2	(0.6)
	1959	0.7	(0.5)	5.5	(5.7)	10.1	(6.2)	1.0	(1.5)
	1969	0.7	(0.5)	3.3	(3.9)	6.6	(7.6)	2.8	(4.1)
Sorghum-Grain	1949	-	(0)	-	(-)	0.1	(0.1)	-	(-)
	1959	0	(0)	-	(-)	1.4	(1.7)	0.6	(11.3)
	1969	0	(0)	-	(-)	1.7	(3.4)	1.5	(4.7)
Sorghum-Silage	1949	-	(-)	-	(-)	-	(-)	-	(-)
	1959	0	(0)	-	(-)	0.5	(0.3)	0.1	(0.3)
	1969	-	(-)	0.1	(0.2)	1.4	(2.1)	0.8	(1.4)
Wheat	1949	60.6	(67.2)	51.7	(53.9)	22.8	(24.6)	8.7	(1.0)
	1959	47.5	(50.6)	34.1	(35.7)	18.0	(16.1)	5.4	(0.4)
	1969	48.2	(50.1)	40.4	(45.0)	14.9	(17.5)	6.3	(0.5)
Small Grains	1949	8.5	(8.4)	19.1	(16.0)	26.9	(19.8)	15.3	(30.8)
	1959	25.6	(24.5)	29.7	(25.0)	28.3	(15.5)	11.7	(24.2)
	1969	24.9	(24.9)	33.0	(26.3)	26.7	(20.1)	8.7	(17.7)
Soybeans for Beans	1949	0	(0)	-	(-)	0.2	(0.1)	-	(-)
	1959	0	(0)	-	(-)	0.8	(0.8)	0.1	(0.4)
	1969	0	(0)	-	(-)	1.6	(2.8)	1.6	(5.4)
Hay	1949	22.7	(19.9)	21.6	(22.5)	25.1	(25.4)	51.2	(16.7)
	1959	23.5	(22.4)	26.7	(29.3)	44.5	(33.9)	59.2	(23.2)
	1969	24.9	(23.7)	22.6	(23.9)	29.0	(29.1)	59.2	(25.6)

(xx) Corridor counties 0 Not reported, - less than 0.1 percent
Source: U. S. Dept. of Commerce, Census of Agriculture
* Within Upper Missouri River Subareas

Table B-7 - VALUE OF FARM PRODUCTS SOLD*
(millions of dollars)

		Montana	North Dakota	South Dakota	Nebraska
Crops	1949	108.1 (46.4)	83.4 (41.7)	114.8 (25.8)	24.3 (7.4)
incl. Hay,	1959	152.8 (59.7)	75.3 (28.9)	78.1 (22.1)	24.4 (8.7)
Nursery	1969	180.8 (74.5)	168.7 (67.4)	200.6 (52.5)	36.4 (13.7)
Livestock,	1949	141.7 (53.0)	74.2 (31.2)	296.3 (73.5)	88.2 (35.8)
Poultry	1959	188.9 (71.3)	112.5 (47.3)	417.5 (106.2)	135.7 (53.9)
	1969	345.6 (120.1)	169.1 (72.7)	719.8 (182.0)	223.8 (85.0)

(xx) Corridor counties

Source: U. S. State Dept. of Commerce, Bureau of Census.

* Within Upper Missouri River Subareas

agricultural base but also as a source for firewood which many depended upon for fuel. The Indians interest in the river and reservoirs remains for its potential for tourism and recreation development and their unique claim to future water use under the Winter's Doctrine, discussed elsewhere in this report.

59. Nearly 80 percent of the tribal, individual Indian, and Government-owned land is used for grazing. About 70 percent of the grazing land is used by Indians, the balance being leased to non-Indians. Other land uses in the Montana-Wyoming reservation areas include: commercial timber, non-commercial timber, dry farmland, and irrigated land. In the Dakotas and Nebraska reservation areas such other land uses include non-commercial timber and dry farmland.

Table B-8 - LANDS IN TRUST OWNERSHIP OR AVAILABLE*
FOR USE AND BENEFIT OF INDIANS

Reservation or Location	Total Acres	Indian Trust Ownership Tribal	Indian Trust Ownership Individual Allotment	Government Owned
			(Percent)	
Montana				
FORT PECK 1/	963,779	24.6	66.4	9.0
(off Reservation)	(8,715)		(100.0)	
Other (Blackfeet, Crow, Northern Cheyenne, Ft. Belknap, Rocky Boy's)	3,704,352	29.1	69.8	0.1
North Dakota				
FORT BERTHOLD	420,882	11.7	88.2	0.04
(off Reservation)	(2,560)		(100.0)	
STANDING ROCK 2/	297,890	28.3	70.4	1.3
South Dakota 3/				
CHEYENNE RIVER	1,410,346	65.1	34.6	0.3
(off Reservation)	(5,448)	(46.1)	(53.9)	
CROW CREEK	124,871	29.0	55.6	15.4
(off Reservation)	(274)		(52.6)	(47.4)
LOWER BRULE	119,944	64.0	25.0	11.0
ROSEBUD	962,333	45.7	51.3	3.0
STANDING ROCK 2/	546,635	43.7	55.1	1.2
YANKTON	34,057	23.6	76.4	
Other (Flandreau, 4/ Pine Ridge) 5/	1,673,109	26.0	68.8	5.2
Nebraska				
SANTEE	5,786	62.2	37.8	
Wyoming				
Wind River	2,907		100.0	

1/ Reservations in CAPS on Missouri River. 2/ Part in ND and SD.
3/ Does not include Sisseton-Wahpeton Res. 4/ Includes school.
5/ Includes 552 AC in NE. Source: USDI, Bureau of Indian Affairs.
* Within Upper Missouri River Subareas.

PROJECTED AGRICULTURAL PRODUCTION

60. Earlier tables indicated the principal crops by harvested acres and the value of farm products sold during selected census years for corridor and non-corridor counties. Projected agricultural production appearing in the OBERS (Series E) Supplement for Agricultural Projections (May 1975) do not provide comparable information. To obtain a breakout of upper basin production, information from the MRB Framework Study itemizes farm production on a current normalized basis. This source reports the area as producing over two-thirds of the Basin total for small grains (barley, oats, and rye), over 40 percent of both hay and wheat, almost one-fourth of the corn silage, about one-sixth of the corn for grain, and among the lesser crops, 99 percent of the flaxseed, one-third of the sugar beets, nearly 30 percent of the dry beans, and over one-fifth of the potatoes. The OBERS projections indicate that by 2020 production of these crops for the Missouri River Basin using the current normal index of 100 will change as follows: small grains 153, hay 214, wheat 177, corn silage 189, corn grain 239, flaxseed 87, sugar beets 157, dry beans 106, and potatoes 55. Since the upper basin's share is relatively high, it is likely the area will play an important part in future production of these crops. On the same basis as above for livestock and livestock products current production in the area is one-third of the beef and veal, one-sixth of the pork, more than one-half of the lamb and mutton, one-seventh of the poultry, one-fourth of the eggs, and one-sixth of the milk. Using a current index of 100, projections for the entire Basin by 2020 indicate beef and veal 246, pork 190, lamb and mutton 24, poultry 158, eggs 33, and milk 59.

61. Projections of the value of crop and livestock and livestock products were made by OBERS-E for the 16 Water Resource Subareas comprising the Missouri River Basin above Sioux City. Using 1969 as a basis equal to 100, the value of crop production in the area is projected to increase to 198 by 1980, 256 by 2000, and 293 by 2020. On the same basis value of livestock production is projected to

102 by 1980, 134 by 2000, and 156 by 2020.

Economics

62. Historic levels of the labor force, employment and unemployment are based on Census reports. Special consideration is given to the current situation regarding Indian populations of the area since, as a group, they represent areas of substantial and chronic unemployment and underemployment. Projected population, employment, income, and earnings among various industrial groups to 2020 are taken from OBERS-E data.

LABOR FORCE

63. The size of the civilian labor force is defined as those who did any work for pay or profit during the survey week, or those who worked 15 hours or more as unpaid workers in a family enterprise, or all persons who were temporarily not at work for non-economic reasons (illness, vacation, etc.). The labor force also includes those who were unemployed but were actively seeking or available for work. Effective January 1967 the minimum age for labor force classification was raised from 14 to 16 years.

EMPLOYMENT AND UNEMPLOYMENT

64. Generally, population levels and trends are related to levels and trends of employment. In the absence of employment opportunities, the resident population tends to be mobile, moving to where employment is available. A resident population will support a portion of the total employment opportunities to provide them with goods and services. Employment within the various industries will be briefly addressed later. Employment to population ratios, both in corridor and non-corridor counties of the upper basin area have historically been slightly lower than those for the Missouri River Region and the Nation as shown in Table B-9. This can be attributed to limited mobility of the labor force.

Table B-9 - LABOR FORCE, EMPLOYMENT AND UNEMPLOYMENT*

		Labor Force (1,000's)	Employment (1,000's)	Employment/ Population (Percent)	Unemployment Rate (Percent)
Montana	1950	159.3	152.4	37.7	9.9
		(70.2)	(67.4)	(37.9)	(4.0)
	1960	175.1	165.2	34.9	5.7
		(78.1)	(73.7)	(34.4)	(5.6)
	1970	178.8	169.3	35.8	5.3
		(82.1)	(77.4)	(35.2)	(5.7)
North Dakota	1950	98.7	95.1	35.8	3.7
		(48.6)	(46.7)	(36.3)	(3.9)
	1960	95.8	90.5	34.0	5.5
		(49.2)	(45.9)	(33.8)	(6.8)
	1970	86.7	82.9	33.8	4.4
		(46.8)	(44.5)	(34.4)	(4.9)
South Dakota	1950	239.9	233.4	37.1	2.7
		(47.95)	(46.8)	(36.6)	(2.4)
	1960	239.9	230.2	35.0	4.0
		(46.5)	(44.6)	(34.6)	(4.0)
	1970	242.0	233.0	34.5	3.7
		(46.5)	(44.9)	(36.6)	(3.4)
Nebraska	1950	40.8	39.9	35.9	2.2
		(16.0)	(15.7)	(36.5)	(1.6)
	1960	38.0	37.1	36.0	2.4
		(13.7)	(13.5)	(34.6)	(1.7)
	1970	33.4	32.7	35.7	2.1
		(12.1)	(12.0)	(34.1)	(1.4)
Missouri River Region	1950	NA	2,682.2	38.4	NA
	1960	NA	2,984.6	37.6	NA
	1970	NA	3,370.7	39.7	NA
United States	1950	62,208	58,920	38.0	5.3
	1960	69,628	65,778	37.0	5.5
	1970	82,715	78,627	39.0	4.9

Note: (xx) Corridor Counties
NA = Not Available
Sources: U. S. Dept. of Commerce Bureau of Census and U.S. Bureau of Labor Statistics.
* Within Upper Missouri River Subareas.

65. Trends or changes in employment have varied during the historic years cited, 1950, 1960, and 1970. Like the region and the Nation the Montana portion of the area has sustained a growth trend in employment; however, the rate of increase was less than one-half of that for the region and about a third of the national increase. The corridor counties increased at a slightly greater rate. North Dakota experienced a continued downtrend in employment over the three years, but corridor counties declined at a much lesser rate. Employment in South Dakota declined from 1950 to 1960, and then recovered to nearly the 1950 level by 1970. Employment in the corridor counties recovered at only one-half the non-corridor rate. Employment in Nebraska declined both in the corridor counties and the remainder of the area.

66. Unemployment in the Montana and North Dakota areas were nearly the same or slightly above the national average in 1950. In South Dakota and Nebraska unemployment remained considerably below the national level.

SECTOR EMPLOYMENT

67. Employment is presented for nine major employment groups extracted from the 1970 Census reports, Table B-10. Trends toward fewer, larger farms and ranches, improved technology and increased production have resulted in dramatic reductions in agricultural employment. In Montana where nearly two-thirds of the farmland is in pasture and range and the average unit is nearly three times larger than similar units in the study area, agricultural employment has declined from nearly 30 percent in 1950 to about one-half that share. Similarly, farm employment in the two Dakotas has declined from 40-50 percent of the total employment to 21-26 percent. The employment sectors displaying the greatest growth potential are the services and government sectors, this is in consonance with national trends.

Table B-10 - EMPLOYMENT BY MAJOR EMPLOYMENT GROUPS - 1970*
(Percent)

Groups	Noncorridor Counties	Corridor Counties	United States
Agriculture, Forestry, Fisheries	21.5	20.6	3.7
Mining	2.3	0.8	0.8
Contract Construction	5.5	6.6	5.8
Manufacturing	6.9	6.2	25.0
Transportation, Communications, Public Utilities	6.4	5.8	6.5
Trade	22.0	21.2	19.6
Finances, Insurance, Real Estate	3.4	3.8	4.9
Services	27.1	28.1	25.9
Public Administration	4.9	6.9	7.8

Source: U. S. Dept. of Commerce, Bureau of Census
* Within Upper Missouri River Subareas

INDIAN LABOR FORCE

68. Of significant economic and social concern in the area is the high level of unemployment and underemployment of reservation Indians displayed in Table B-11. In a March 1973 Labor Force Report by the Bureau of Indian Affairs the participation rate, (percentage of population in the labor force), was generally below that for the non-Indian population, but this was due in part to the large portion of the total population under 16 years of age, nearly 50 percent. While the B.I.A. offers job training and relocation services, many

Table B-11 - INDIAN LABOR FORCE AND EMPLOYMENT*
MARCH 1973

Reservation	Population 1/ In Labor Force Male (Percent)	Population 1/ In Labor Force Female (Percent)	Number Employed Male	Number Employed Female	Unemployed Male (Percent)	Unemployed Female (Percent)
Montana						
FORT PECK 2/	12.4	9.6	403	299	26.9	21.8
Other (Blackfeet, Crow, Northern Cheyenne, Ft. Belknap, Rocky Boy's)	34.8	22.2	1,773	1,276	39.0	31.5
North Dakota						
FORT BERTHOLD	18.4	15.8	409	204	10.6	24.9
STANDING ROCK 3/	13.4	12.6	278	178	12.3	23.4
South Dakota 4/						
CHEYENNE RIVER	17.8	9.8	529	354	20.2	6.0
CROW CREEK	18.6	13.3	68	53	41.1	28.3
LOWER BRULE	13.7	7.4	80	38	10.8	9.5
ROSEBUD	15.1	8.6	843	541	16.4	6.2
STANDING ROCK 3/	13.4	12.6	218	141	12.4	23.4
YANKTON	23.2	13.5	42	39	55.1	29.4
Other (Pine Ridge, Flandreau)	32.3	17.9	944	873	50.3	17.3
Nebraska						
SANTEE	15.1	18.2	44	16	8.4	41.2
Wyoming						
Wind River	14.5	9.2	360	200	27.8	20.2

1/ March 1973 Labor Force Report. 2/ Reservations in CAPS on Missouri River. 3/ Part in ND and SD. 4/ Not including Sisseton-Wahpeton Reservation. Source: USDI, Bureau of Indian Affairs.
* Within Upper Missouri River Subareas

of the reservation residents choose to remain in the area because of cultural and/or family reasons, despite a paucity of employment opportunities. Unemployment rates at the time of the report ranged from about 20 to nearly 85 percent among the nine reservations located adjacent to the main stem projects.

PROJECTED POPULATION AND EMPLOYMENT

69. Projections of population, income, employment, and earnings were taken from the 1972 OBERS Series E projections prepared for the Water Resources Council. Data were available for Water Resources Subareas and state portions of subareas as shown in Table B-12. It is considered that these rates are indicative of future trends in the corridor counties where site-specific data are unavailable.

EARNINGS

70. Because total earnings represent two-thirds to three-fourths of total personal income, the projected trends in earnings follow closely those of income. In the MRB and the Nation, total earnings represent a slightly greater portion of total income through the projection period. The measure of earnings per employee varies between the state portions of the basin, the region, and the United States due to employment mix and earnings levels among the different industries. The near-term projections place the regional average at $12,200 and the national average at $13,200 in 1980. The projected levels of earnings per employee for the MRB in 2020 are $33,100 and the U. S. are $34,700.

71. Projected distribution of earnings by industrial group appears in Tables B-13 and B-14. During the period from 1980 to 2020 the earnings are expected to increase about 2.2 times in Nebraska and 2.8 times in the remaining three states compared to 3.4 times in the MRB and 3.6 times in the U. S. Only the agricultural sector displays a significant decline while the service and government sectors increase somewhat.

Table B-12 - PROJECTIONS OF POPULATION, INCOME,*
EMPLOYMENT, AND EARNINGS

		Montana	North Dakota	South Dakota	Nebraska
Population (1,000's)	1980	455	229	637	81
	2000	446	217	621	66
	2020	449	207	618	59
Total Personal Income (millions of 1975 dollars)	1980	2,997	1,313	3,864	471
	2000	5,106	2,228	6,628	676
	2020	8,577	3,642	11,003	1,008
Income Per Capita (1,000's of 1975 dollars)	1980	6.6	5.7	6.1	5.8
	2000	11.5	10.3	10.7	10.2
	2020	19.1	17.6	17.8	17.2
Total Employment (1,000's)	1980	188	87	262	31
	2000	194	88	267	26
	2020	195	85	263	23
Total Earnings (millions of 1975 dollars)	1980	2,292	938	2,904	323
	2000	3,865	1,658	4,929	466
	2020	6,448	2,705	8,174	700
Earnings Per Employee (1,000's of 1975 dollars)	1980	12.2	11.3	11.1	10.6
	2000	20.0	18.8	18.5	17.8
	2020	33.1	31.7	31.1	30.2

Source: 1972 OBERS Projections, Regional Economic Activity In The U. S. (Series "E"), U. S. Water Resources Council, April 1974.

* Within Upper Missouri River Subareas

Table B-13 - PERCENTAGE DISTRIBUTION*
OF PROJECTED EARNINGS
BY INDUSTRIAL GROUP

Montana

	1980	2000	2020
Agriculture, Forestry, Fisheries	16.0	11.1	8.4
Mining	1.2	1.0	0.8
Contract Construction	5.9	5.7	5.3
Manufacturing	7.3	6.8	6.3
Transportation, Communications, Public Utilities	8.5	7.6	7.1
Trade (Wholesale - Retail)	17.0	16.6	16.0
Finance, Insurance, Real Estate	4.5	5.2	5.5
Services	16.0	19.5	22.0
Civilian Government	20.4	23.4	25.6
Federal Military	3.2	3.1	3.0
Total	100.0	100.0	100.0

North Dakota

	1980	2000	2020
Agriculture, Forestry, Fisheries	22.2	17.9	14.3
Mining	1.8	1.3	1.1
Contract Construction	5.4	5.4	5.2
Manufacturing	4.9	5.3	5.4
Transportation, Communications, Public Utilities	7.7	7.3	7.1
Trade (Wholesale - Retail)	19.3	18.8	18.4
Finance, Insurance, Real Estate	3.5	4.0	4.3
Services	15.3	19.0	21.9
Civilian Government	19.0	20.2	21.5
Federal Military	0.9	0.8	0.8
Total	100.0	100.0	100.0

* Within Upper Missouri River Subareas

Table B-14 - PERCENTAGE DISTRIBUTION* OF PROJECTED EARNINGS BY INDUSTRIAL GROUP

South Dakota

	1980	2000	2020
Agriculture, Forestry, Fisheries	21.9	16.2	12.4
Mining	1.1	0.8	0.7
Contract Construction	4.8	4.8	4.7
Manufacturing	8.5	8.9	8.9
Transportation, Communications, Public Utilities	5.8	5.7	5.7
Trade (Wholesale - Retail)	16.9	16.5	16.0
Finance, Insurance, Real Estate	4.0	4.5	4.8
Services	14.8	18.1	20.6
Civilian Government	19.4	21.8	23.5
Federal Military	2.8	2.7	2.7
Total	100.0	100.0	100.0

Nebraska

	1980	2000	2020
Agriculture, Forestry, Fisheries	42.3	33.7	28.5
Mining	0.1	0.1	0.1
Contract Construction	2.2	2.1	2.0
Manufacturing	3.3	4.4	5.1
Transportation, Communications, Public Utilities	6.7	7.2	7.4
Trade (Wholesale - Retail)	16.1	16.9	17.1
Finance, Insurance, Real Estate	2.9	3.6	4.0
Services	11.7	15.0	17.4
Civilian Government	14.4	16.7	18.1
Federal Military	0.3	0.3	0.3
Total	100.0	100.0	100.0

* **Within Upper Missouri River Subareas**

Recreation Resources

72. The main stem reservoir projects attract the vast majority of recreationists on the Missouri River within the study reach. During the 1967-1975 period, total average annual visitation at the six main stem lakes was 8.2 million. As a comparison of passing interest, the total population of the four states containing or bordering these projects is less than 3.5 million.

SCORP FINDINGS

73. Recreation demand estimates reported in Statewide Comprehensive Outdoor Recreation Plans (SCORP), although general in scope, are useful in forming broad evaluations. From these plans it is apparent that:

- A significant but quantitatively undeterminable level of recreational use is made of all open river reaches and related resources. Floating and fish-and-wildlife-oriented recreation appear to be the primary activities in all reaches except below Gavins Point Dam where other activities, especially powerboating between Ponca State Park and Sioux City, Iowa, predominate.
- Relatively low population density throughout the reach above Sioux City markedly restricts current recreational demand levels.
- Most riparian land is privately owned, a factor which discourages full accommodation of demand.

SPONSORSHIP

74. Accommodation of recreation demands at the lake projects is generally adequate at the present time, and with the exception of improved access, no major facilities expansion is needed in the immediate future. Certain minor developments such as additional launching points are desirable but are contingent upon non-Federal sponsorship to provide at least one-half of the development cost and assume all of the operation, maintenance, and replacement responsibility. This reluctance by potential sponsors of recreation development to dedicate funds for expenditure on Federal lands, or to make long-term management commitments is presently deterring expansion

of facilities and could some day result in overuse of existing developments; however, there is no evidence that this is a significant problem at the present level of demand.

MONTANA

75. About 5 percent of Montana respondents to the 1971-72 survey reported in the SCORP preferred to recreate at intensively developed areas. The remaining 95 percent preferred a natural, outstanding, primitive, general, or historical and cultural setting for their outdoor recreation activities. About 25 percent preferred the "General Outdoor Recreation" category as typified by most State Parks and developed areas at Corps lake projects.

76. Among the SCORP recommendations for Federal action germane to this report are "... Make available the recreation opportunities inherent in the large multi-purpose projects." and to "devise exemplary policies and standards" in the recreation field. A frequently cited opportunity for improvement is the almost total absence of all-weather access roads to recreation areas on the lake proper.

77. Fort Peck Lake features nine major recreation developments, three of which are State Parks. Annual visitation has increased from 256,000 in 1964 to over 700,000 in 1975. The 1971-75 average annual visitation was approximately 660,000. Approximately 40 percent of this visitation is at the Downstream and Dredge Cuts areas.

NORTH DAKOTA

78. SCORP surveys in North Dakota also revealed popular demand for outdoor recreation. Although the types of areas preferred were not investigated, reports on preferred activities mentioned picnicking, fishing, hunting, boating, camping, visiting historical areas, and snowmobiling. None of the recommendations for Federal action significant to Lake Sakakawea contained in the 1975 North Dakota SCORP appear to require formulation in this report because development of

the additional recreation desired can be provided under existing authority when and where local sponsors are willing to cost-share.

79. Lake Sakakawea is wholly contained within North Dakota. There are 28 developed recreation areas at Lake Sakakawea, including two State Parks. Average annual visitation for 1971-75 has been 1,129,000. About 15 percent of the total annual visitation is recorded at the downstream areas. All-weather access is available to most major recreation areas at this project, however, some improvements are needed, particularly at the Little Missouri recreation area.

SOUTH DAKOTA

80. In South Dakota, recreationists generally express preferences similar to those discussed in the previous two states. As one proceeds downstream, however, to the vicinity of Sioux City and the increasing influence of the Omaha SMSA, the population density increases. The additional recreation demand exerted by the greater population, results in a lesser per capita opportunity available on private lands. This, in turn, has led residents of the area to be more tolerant of increased user density in preferred recreation areas. Intensive study should reveal significant changes in both resident recreation demand and need along the Missouri River downstream from the vicinity of Fort Randall Dam as compared to the upstream area.

81. Four main stem lakes are located at least partly in South Dakota. Lake Oahe lies partly in North Dakota, and Lewis and Clark Lake divides its shores between South Dakota and Nebraska. Lakes Sharpe and Francis Case are wholly within South Dakota.

Lake	Developed Recreation Areas	Average Visitation 1971-75	Percent Visitation at Downstream Areas
Oahe	26	1,913,000	12 - 16
Sharpe	15	732,000	30 - 40
Francis Case	17	1,403,000	17 - 20
Lewis and Clark	25	2,993,000	50 - 70

82. The South Dakota SCORP recommendation for Federal action of particular interest to this study is that "Management plans for Federal areas should provide special consideration for wilderness areas, primitive areas and natural areas."

83. Lakes Oahe and Francis Case were well known for trophy sized Northern Pike fishing in the past and this activity attracted significant numbers of out-of-State visitors. When normal operating pool levels were attained, however, less pike reproduction occurred resulting in a significant decline of the population. At present, the most attractive fishery at Fort Randall is in the tailrace, drawing fishermen from as far as Omaha for the spring runs of Sauger and Walleye. Walleye fishing in Lake Oahe and the Oahe tailwater is also popular with the project visitor.

NEBRASKA

84. The principal recommendation for Federal action in the Nebraska SCORP which relates to this study is "To acquire and manage for public enjoyment only those additional resources that are truly national in importance, uniqueness, or scope ..... or such resources which are interstate in character; or which provide identifiable recreation opportunities associated with multiple-purpose projects ..."

TOURIST TRAFFIC

85. Non-resident recreation demand has decreased markedly at Lakes Oahe and Francis Case in concert with the decline in populations of

trophy sized Northern Pike. At the present time, the bulk of non-resident vacation traffic at these lakes consists of transient campers near interstate highways. Most of these travelers are enroute to or returning from traditional vacation areas including the Black Hills, Rocky Mountains, and the western National Parks and Monuments. While non-resident vacation traffic is a significant factor in the economy of each of the States containing or bordering the Missouri River above Sioux City, the river and its resources do not contribute to this economy in highly significant ways at the present time.

The Main Stem Reservoir System

86. The six Missouri River main stem dams are located along a thousand-mile stretch of river extending from Yankton, South Dakota to Glasgow, Montana. An embankment volume of 125 million cubic yards makes Fort Peck the second largest earthen dam in the world. Oahe follows as number three. At the base of the flood control pools the lakes behind these six dams offer a million acres of flat water; at full pool, they total 755 miles in length.

87. Spillway discharge capabilities range from 275,000 to 827,000 cfs. Each project produces hydro-power, with plant capacities ranging from 100,000 kw to 595,000 kw for a total of 2,048,000 kw. Annual generation averages more than 9 billion kilowatt hours. Total flood damages prevented by the system through 1975 exceed $1,400,000,000 in 1975 dollars. Over 8 million recreation days are accumulated by the projects each year. Immediately downstream of the study area a 730-mile navigation channel moves traffic which in the 1976 season amounted to just over three million tons.

<u>OPERATING ZONES</u>

88. The reservoirs contain an aggregate storage space of 74,625,000 acre-feet, more than three times the average annual flow of the Missouri River at the lowermost dam. Functionally, the main stem reservoirs and powerplants operate as a hydraulically and electrically

integrated system. All reservoirs except Lake Sharpe and Lake Lewis and Clark have the storage divided into four zones, as listed in Table B-15 and described below.

89. Exclusive Flood Control Zone - The top zone of 4,720,000 acre-feet, 6 percent of the total storage, is reserved exclusively for flood control. Impoundments in this zone are evacuated as soon as downstream conditions permit, in the interest of having space available to control future floods, should they occur.

90. The Annual Flood Control and Multiple-Use Zone which lies below the Exclusive Flood Control Zone contains 11,710,000 acre-feet, 16 percent of the total storage space. Reservoir regulation criteria are designed to empty this zone by 1 March of each year. The zone is then filled to the extent inflows permit or flood control considerations require in the March to July high-water season, and then drawn down for multiple purposes during the low-flow season which extends from late summer through winter.

91. The Carryover Multiple-Use Zone of 39,700,000 acre-feet, 53 percent of the total storage, provides a reserve of multiple-use storage for serving navigation, power, irrigation, and other functions during prolonged low-flow periods of several years' duration. In event of a recurrence of an extended drought period such as the 1930's, it would be necessary to empty this storage zone to maintain service to all functions.

92. The Inactive Zone provides an assured minimum pool level for power, irrigation pump diversions, recreation, fish and wildlife purposes, and provides storage capacity for sediment accumulation. It contains 18,495,000 acre-feet, 25 percent of the total.

REGULATION CRITERIA & FUNCTIONAL OPERATION

93. In the planning for, and the operation of, the main stem

TABLE B-15 SUMMARY OF ENGINEERING DATA — MISSOURI RIVER MAIN STEM RESERVOIRS

ITEM NO.	SUBJECT	FORT PECK LAKE	GARRISON DAM — LAKE SAKAKAWEA	OAHE DAM — LAKE OAHE	BIG BEND DAM — LAKE SHARPE	FORT RANDALL DAM — LAKE FRANCIS CASE	GAVINS POINT DAM — LEWIS & CLARK LAKE	TOTAL	ITEM NO.
1	Location of Dam	Near Glasgow, Montana	Near Garrison, N. Dak	Near Pierre, S. Dak	21 mi upstream Chamberlain, S. D	Near Lake Andes, S. Dak	Near Yankton, S. Dak		1
2	River Mile — 1960 mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3	Mile 987.4	Mile 880.0	Mile 811.1		2
3	Total & incremental Drainage Areas, square miles	57,500	181,400 (2) 123,900	243,480 (1) 64,090	249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3
4	Approximate length of full Reservoir (*in Valley Miles*)	134, ending near Zortman, Mont.	178, ending near Trenton, N. D	231, ending near Bismarck, N. D	80, ending near Pierre, S. D	107, ending at Big Bend Dam	25, ending near Niobrara, Nebr	755 Miles	4
5	Shoreline — Miles (3)	1520 (*El. 2234*)	1340 (*El. 1837.5*)	2250 (*El. 1607.5*)	200 (*El. 1420*)	540 (*El. 1350*)	90 (*El. 1204.5*)	5,940 miles	5
6	Average total & incremental inflow in cfs	9,900	25,200 15,300	28,400 3,200		29,500 1,100	31,400 1,900		6
7	Max. Discharge of Record near Damsite in cfs	137,000 (*June 1953*)	348,000 (*April 1952*)	440,000 (*April 1952*)	440,000 (*April 1952*)	447,000 (*April 1952*)	480,000 (*April 1952*)		7
8	Construction started — Cal. yr.	1933	1946	1948	1959	1946	1952		8
9	In operation (4) Cal. yr.	1940	1955	1962	1964	1953	1955		9
	DAM AND EMBANKMENT								
10	Top of Dam, Elev. ft. msl	2280.5	1875	1660	1440	1395	1234		10
11	Length of Dam in feet	21,026 (*excluding spillway*)	11,300 (*including spillway*)	9,300 (*excluding spillway*)	10,570 (*including spillway*)	10,700 (*including spillway*)	8,700 (*including spillway*)	71,596 feet	11
12	Damming Height, feet (5)	220	180	200	78	140	45	863 feet	12
13	Maximum Height, feet (5)	250.5	202	245	95	165	74		13
14	Max. Base width, total & w/o Berms, feet	3500;2700	3400;2050	3500,1500	1200;700	4300,1250	850,450		14
15	Abutment Formations (*Under Dam & Embankment*)	Bearpaw shale and Glacial Till	Fort Union Clay-Shale	Pierre shale	Pierre shale & Niobrara chalk	Niobrara Chalk	Niobrara chalk & Carlile shale		15
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth fill	Rolled earth fill & shale berms	Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16
17	Fill quantity, cu. yds	125,628,000	66,500,000	55,000,000 & 37,000,000	17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17
18	Volume of concrete (*Cu. yds.*)	1,200,000	1,500,000	1,045,000	540,000	961,000	308,000	5,554,000 cu. yds	18
19	Date of closure	24 June 1937	15 April 1953	3 August 1958	24 July 1963	20 July 1952	31 July 1955		19
	SPILLWAY DATA								
20	Location	Right bank — remote	Left bank — Adjacent	Right bank — remote	Left bank — adjacent	Left bank — adjacent	Right bank — adjacent		20
21	Crest Elevation, msl	2225	1825	1596.5	1385	1346	1180		21
22	Width (*including piers*) in feet	820 gated	1336 gated	456 gated	376 gated	1000 gated	664 gated		22
23	No., Size and Type of Gates	16—40'x25' Vertical Lift Gates	28-40'x29' Tainter	8-50'x23.5' Tainter	8-40'x38' Tainter	21-40'x29' Tainter	14-40'x30' Tainter		23
24	Design Discharge Capacity, cfs	275,000 at elev. 2253.3	827,000 at elev. 1858.5	304,000 at elev. 1644.4	390,000 at elev. 1433.6	620,000 at elev. 1379.3	584,000 at elev. 1221.4		24
25	Discharge Capacity at Maximum Operating Pool, cfs	230,000	660,000	80,000	232,000	508,000	345,000		25
	RESERVOIR DATA (6)								
26	Max. Operating Pool Elev. & Area	2250 msl 249,000 acres	1854 msl 383,000 acres	1620 msl 371,000 acres	1423 msl 61,000 acres	1375 msl 102,000 acres	1210 msl 32,000 acres	1,198,000 acres	26
27	Max. Nor. Op. Pool Elev. & Area	2246 msl 240,000 acres	1850 msl 368,000 acres	1617 msl 356,000 acres	1420 msl 57,000 acres	1365 msl 95,000 acres	1208 msl 30,000 acres	1,146,000 acres	27
28	Base Flood Control Elev. & Area	2234 msl 212,000 acres	1837.5 msl 315,000 acres	1607.5 msl 313,000 acres	1420 msl 57,000 acres	1350 msl 79,000 acres	1204.5 msl 26,000 acres	1,002,000 acres	28
29	Min. Oper. Pool Elev. & Area	2160 msl 92,000 acres	1775 msl 129,000 acres	1540 msl 116,000 acres	1415 msl 51,000 acres	1310 msl 36,000 acres	1195 msl 15,000 acres	441,000 acres	29
	Stor. Allocation, Elev. & Cap.								
30	Exclusive Flood Control	2250-2246 1,000,000 a.f.	1854-1850 1,500,000 a.f. (10)	1620-1617 1,100,000 a.f.	1423-1422 60,000 a.f.	1375-1365 1,000,000 a.f.	1210-1208 60,000 a.f.	4,720,000 a.f.	30
31	Flood Control & Multiple Use	2246-2234 2,700,000 a.f.	1850-1837.5 4,300,000 a.f. (10)	1617-1607.5 3,200,000 a.f.	1422-1420 115,000 a.f.	1365-1350 1,300,000 a.f.	1208-1204.5 95,000 a.f.	11,710,000 a.f.	31
32	Carryover Multiple Use	2234-2160 10,900,000 a.f.	1837.5-1775 13,400,000 a.f. (10)	1607.5-1540 13,700,000 a.f.		1350-1320 1,700,000 a.f.		39,700,000 a.f.	32
33	Inactive	2160-2030 4,300,000 a.f.	1775-1673 5,000,000 a.f.	1540-1415 5,500,000 a.f.	1420-1345 1,735,000 a.f.	1320-1240 1,600,000 a.f.	1204.5-1160 360,000 a.f.	18,495,000 a.f.	33
34	Gross	2250-2030 18,900,000 a.f.	1854-1673 24,200,000 a.f. (10)	1620-1415 23,500,000 a.f.	1423-1345 1,910,000 a.f.	1375-1240 5,600,000 a.f.	1210-1160 515,000 a.f.	74,625,000	34
35	Reservoir filling initiated	November 1937	December 1953	August 1958	November 1963	January 1953	August 1955		35
36	Initially reached Min. Oper. Pool	27 May 1942	7 August 1955	3 April 1962	25 March 1964	24 November 1953	22 December 1955		36
37	Est. Annual Sediment Inflow	17,500 a.f.	38,100 a.f.	32,300 a.f.	4,400 a.f.	16,500 a.f.	2,500 a.f.	111,400 a.f.	37
	OUTLET WORKS DATA								
38	Location	Right bank	Right bank	Right bank		Left bank			38
39	Number and size of conduits	2—24'8" dia (*No's. 3 & 4*)	1-26' dia. and 2-22' dia	6-19.75' dia. upstream, 18.25' dia. downstream	None (7)	4-22' diameter	None (7)		39
40	Length of Conduits in feet (8)	No. 3—6,615, No. 4—7,240	1529	3496 to 3659		1013			40
41	No., Size and Type of Service Gates	1—28' dia. cylindrical gate 6 ports 7.6'x8.5' high (*net opening*) in each control shaft	1-18'x24.5' Tainter gate per conduit for fine regulation	1-13'x22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (*fine regulation*)		2-11'x23' per conduit, vertical lift, cable suspension, also one vert. lift fine regulating gate at d.s. end of tunnel #10			41
42	Entrance Invert Elevation	2095	1671.9	[illegible]	1385 (12)	1229	1180 (12)		42
43	Avg. Discharge Cap. per conduit & total	Elev. 2250 22,500 cfs—45,000 cfs	Elev. 1854 32,700 cfs-98,000 cfs	Elev. 1620 18,500 cfs-111,000 cfs		Elev. 1375 32,000 cfs-128,000 cfs			43
44	Present Tailwater Elev. (msl)	2033—2037 10,000—25,000 cfs	1674-1680 25,000-60,000 cfs	1423-1428 25,000-50,000 cfs	1351-1352 (11) 25,000-50,000 cfs	1234-1238 25,000-50,000 cfs	1161-1165 30,000-50,000 cfs		44
	POWER FACILITIES AND DATA								
45	Avg. Gross Head avail. in ft. (13)	193	157	173	69	115	45	752 feet	45
46	Number and size of conduits	No. 1 24'8" dia., No. 2-22'4" dia	5-29' dia., 25' penstocks	7-24' dia., imbedded penstocks	None, direct intake	8-28' dia., 22' penstocks	None, direct intake		46
47	Length of conduits in feet (8)	No. 1-5,653, No. 2-6,355	1,829	From 3,280 to 4,005		1,074		55,083 feet	47
48	Surge Tanks	PH#1: 3-40' dia., PH#2: 2-65' dia	65' dia., 2 per penstock	70' dia., 2 per penstock	None	59' dia., 2 per alternate penstock	None		48
49	No., type and speed of turbines	5-Francis, PH#1-2-128.5, 1-164 rpm, PH#2-2-128.6 rpm	5-Francis, 90 rpm	7-Francis, 100 rpm	8-Fixed blade, 81.8 rpm	8-Francis, 85.7 rpm	3-Kaplan, 75 rpm	36 Units	49
50	Disch. Cap. at Rated Head, cfs	PH#1 units 1&3 170', 2-140' 7,800 cfs, PH#2-2-170' 7,200 cfs	150' 37,800 cfs	185' 54,000 cfs	67' 103,000 cfs	112' 45,000 cfs	48' 33,300 cfs		50
51	Generator Rating, kw	2-35,000, 1-15,000, 2-40,000	80,000	85,000	58,500	40,000	33,333		51
52	Plant capacity, kw	165,000	400,000	595,000	468,000	320,000	100,000	2,048,000 kw	52
53	Dependable capacity, kw (9)	173,000	351,000	526,000	538,000	287,000	67,000	1,941,000 kw	53
54	Average Annual Energy, Million kwh (13)	1,019	2,307	2,672	963	1,732	657	9,371	54
55	Initial Gen., First & Last Unit	July 1943 — June 1961	January 1956 — October 1960	April 1962 — June 1963	October 1964 — July 1966	March 1954 — January 1956	September 1956 — January 1957	July 1943 — July 1966	55
56	Estimated cost January 1976 Completed project	$158,600,000	$299,900,000	$346,200,000	$106,800,000	$197,400,000	$48,100,000	$1,154,100,000	56

REMARKS

(1) Includes 4,280 square miles of non-contributing areas.
(2) Includes 1,350 square miles of non-contributing areas.
(3) With pool at base of flood control.
(4) Storage first available for regulation of flows.
(5) Damming height is height from low water to maximum operating pool. Maximum height is from average streambed to top of dam.
(6) Based on latest available storage data.
(7) River regulation is attained by flows over low-crested spillway and through turbines.
(8) Length from upstream face of intake to downstream face of outlet or to spiral case.
(9) Based on 4th year of drought drawdown. (From 1970 level study 1-74-1970)
(10) Storage volumes are exclusive of Snake Creek arm.
(11) Affected by level of Lake Francis Case. Applicable to pool at elevation 1350.
(12) Spillway Crest.
(13) Based on study 1-74-1970.

Corps of Engineers, U.S. Army
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reservoirs, the general criteria and procedures have been:

- To maintain adequate reservoir storage space available for flood control on the Missouri River.
- To provide water for irrigation, municipal and industrial use.
- To make releases from the lower end of the main stem system to supply the varying seasonal requirements of navigation and water quality control, thereby providing adequate water levels for municipal water intakes as well.
- To generate electrical energy as required to meet system loads, consistent with the other primary functions of flood control, irrigation, and navigation.
- To incorporate special operations responsive to requirements of fish and wildlife and recreation insofar as practical.

FLOOD CONTROL

94. Flood control operations of the main stem reservoirs are aimed at controlling floods on reaches of the Missouri River between reservoirs, and minimizing flood damages from Gavins Point Dam downstream to the mouth of the Missouri River. The main stem reservoirs are operated in conjunction with many tributary reservoirs and the lower river levees and local protection systems for control of floods on the Missouri River.

IRRIGATION

95. Service to major Federal irrigation projects now under construction is expected to begin early in the next decade. The principal functions of the main stem reservoirs will be to provide water from storage during periods of deficient flows, to reduce diversion pumping heads, and to provide flow regulation to offset the depleting effects of upstream tributary irrigation projects on the water supply available for lower river use. Operating goals of the reservoir system will consist principally in maintaining adequate pool levels and river flow rates to supply the irrigation pumping stations during the growing season.

NAVIGATION

96. Operation of the main stem reservoir system for navigation involves releasing water from the lowermost reservoirs of the system at sufficient rates for maintenance of adequate channel depths in the 730-mile open-channel, Missouri River navigation project between Sioux City and the mouth of the Missouri during the navigation season. Ice conditions normally limit navigation releases to an 8-month season, from late March to late November. In future years, some reduction in length of navigation seasons will be necessary after a series of critically low flow years. Substantially lower releases are made during the non-navigation season to maintain satisfactory water quality in the river and to provide winter power generating levels compatible with the summer production rate.

POWER

97. Generation of electrical energy calls for close coordination between the Corps of Engineers' employees who operate the main stem system and the Bureau of Reclamation marketers and dispatchers of the Basin's Federally-produced power. Releases are rarely made with power as the sole consideration; flood control, navigation, recreation, and fish and wildlife receive ongoing consideration. By law the Bureau gives preference in the sale of power to public bodies and cooperatives; commonly there is a substantial remainder for sale to private utilities after preference needs have been met. In addition, off-peak power is purchased whenever necessary to conserve hydro resources for use during peak load periods, thereby reducing oil and gas consumption throughout the marketing area. Transmission lines from the six power plants tie into a nationwide interconnection which links over 90 percent of the 48-state electrical capacity. Full gate discharge through the power plants ranges from 15,000 cfs at Fort Peck to 103,000 cfs at Big Bend. Except for Gavins Point, these ratings are sufficient to accommodate nearly all release requirements. Over the years, less than two percent of project releases have been "spills" - flows which by-passed the power turbines

because of insufficient capacity.

98. Drouth period rule curves for the main stem system are designed to deplete the 40 million acre-feet of multiple-use storage during a repetition of the most critical period of record - the 12-year sequence from 1930 through 1941. One characteristic of these curves is curtailment of downstream releases as upstream depletions grow; the result is a quite uniform draft on storage regardless of the depletion level.

99. Since the "drouth of the '30's" has a recurrence interval many times the life of the main stem projects, its full impact is considered too severe a test by which to determine dependable capacity. This concept was detailed in a 1953 publication of the Missouri Basin Interagency Committee, entitled "Power Requirements and Supply, Missouri River Region." Having noted the severity of a 12-year drouth, the report continues, "therefore, to reflect adverse conditions, it is considered reasonable to select the generation that might be expected at the end of the 4th year (1933) of such a drouth. A 4-year period is sufficiently long to permit stepping up scheduled steam capacity so as to substitute for hydro capacity during any continuance of the drouth period." The 1958 Main Stem Reservoir Cost Allocation and subsequent payout studies and marketing analyses have conformed to this concept.

100. Winter peak loads have historically been higher than summer peaks in the Bureau's marketing area and capability on December 31, 1933 was used as a measure of dependable capacity. This load area, in common with most others, is shifting to a summer peak. August 31, 1933 has become the measure of dependable capacity for future planning and is so used in this report.

WATER QUALITY

101. Water quality throughout the main stem system is generally

excellent. In some instances the reservoirs tend to improve downstream water quality. Measured differences between reservoir inflows and releases indicate that processes within the reservoirs such as absorption, adsorption, volatization, dilution and plant or animal uptake may reduce the concentration of some undesirable components to acceptable levels. Table B-16 shows the measured values at the six main stem lakes for those parameters which have fallen below existing state limits or water quality criteria proposed by the EPA. Several of these values are point sources and are not to be taken as indicators of general water quality throughout the lake.

102. Water quality is in part a reflection of the drainage basin. Parameters such as mercury, alkalinity, pH and sulfates which occasionally exceed water quality limits are associated with the Missouri River drainage and common to much of the main stem system as indicated in Table B-16. Little can be done to alleviate these exceedences of natural origin.

103. Turbidity levels of water releases from all of the main stem dams, except Fort Peck, often exceed existing water quality standards. The nature of the material causing the turbidity is usually organic and is probably produced in the lakes although this has not been verified in most instances. The existing turbidity levels have not caused any problems in downstream areas and may be beneficial to planktivorous fishes as a food source.

104. Water temperature exceedences have occurred in three main stem areas: Fort Peck, Oahe and Lake Sharpe. It should be mentioned that these are rare occurrences. Water released downstream comes from deep in the reservoir and is normally well below the existing maximum temperature limits.

105. Phosphorus is another parameter that is sometimes in exceedence of existing water quality criteria for most of the main stem

Table B-16 - WATER QUALITY PARAMETERS
WHICH EXCEED PROPOSED OR EXISTING STATE STANDARDS
FOR LAKES AND LAKE RELEASES
1975

Parameter	RELEASES State Standard Limit	RELEASES Proposed Criteria Limit	RELEASES Greatest Measured Concentration	LAKES State Standard Limit	LAKES Proposed Criteria Limit	LAKES Most Critical Measured Concentration
FORT PECK - FORT PECK LAKE						
pH, Standard Units		8.3	8.7		8.3	8.7
Alkalinity, mg/l		130	191		130	187
Total Phosphorus, mg/l		0.025	0.06			
Mercury, ug/l		0.2	13.0		0.2	14.0
Selenium, ug/l	10	10	40			
Water Temperature, ^{0}F				67		76
Ammonia, mg/l				0.5	0.16	1.8
GARRISON DAM - LAKE SAKAKAWEA						
pH, Standard Units	8.5	8.3	8.7	8.5	8.3	8.9
Alkalinity, mg/l		130	171		130	324
Turbidity, JTU	10		25	10		4600
Dissolved solids, mg/l	500	500	536	500	500	565
Mercury, ug/l		0.2	8			
Dissolved Oxygen, mg/l				5		4.8
Ammonia, mg/l				0.12		0.24
Total Phosphorus, mg/l					0.1	0.7
Sulfate, mg/l					250	375
Clarity, Secchi Disk, Ft.					4	3
OAHE DAM - LAKE OAHE						
Water Temperature, ^{0}F	64		70	64		75
pH, Standard Units	8.3	8.3	8.7	8.3	8.3	8.7
Turbidity, JTU	10		25	10		63
Alkalinity, mg/l		130	168		130	168
Total Phosphorus, mg/l		0.025	0.06	0.1	0.025	0.84
Mercury, ug/l		0.2	15		0.2	4
Ammonia, mg/l					0.15	0.29
BIG BEND - LAKE SHARPE						
pH, Standard Units	8.3	8.3	8.7	8.3	8.3	8.7
Mercury, ug/l		0.2	5			
Sulfates, mg/l		250	274			
Water Temperature, ^{0}F				65		80
Turbidity, JTU				10		25
FORT RANDALL DAM - LAKE FRANCIS CASE						
pH, Standard Units	8.3	8.3	8.7	8.3	8.3	8.7
Alkalinity, mg/l		130	201		130	201
Total Phosphorus, mg/l		0.025	0.06		0.025	0.06
Sulfates, mg/l		250	257		250	260
Mercury, ug/l		0.2	3		0.2	1.2
Turbidity, JTU				50		240
Iron, mg/l				0.2	0.3	1.11
Manganese, mg/l					0.05	0.2
GAVINS POINT DAM - LEWIS AND CLARK LAKE						
pH, Standard Units	8.3	8.3	8.7	8.3	8.3	8.7
Alkalinity, mg/l		130	186		130	186
Turbidity, JTU	50		84	50		84
Sulfate, mg/l		250	256		250	256
Mercury, ug/l		0.2	3			
Total Phosphorus, mg/l		0.025	0.33		0.025	0.09

system. The source has not been documented, however, phosphorus levels have caused no reported problems in downstream areas.

106. Many of the existing exceedences of water quality criteria are extremely localized and are commonly associated with some local influence or point source. For instance, several exceedences are associated with the White River delta such as turbidity, iron and manganese. These pollutants are apparently picked up in the White River drainage and subsequently deposited in Lake Francis Case. These problems are quite localized and cause no problems either to the lake or the system as a whole.

RELEASES FOR DOWNSTREAM WATER QUALITY

107. Downstream flow requirements established by the Federal Water Pollution Control Administration in 1969 were re-affirmed by the Environmental Protection Agency in 1974, after consideration of: (1) the current status of PL 92-500 programs for managing both point and non-point waste sources discharging into the river and (2) the satisfactory adherence to the 5.0 ppm dissolved oxygen requirement of federally-approved water quality standards.

108. The values tabulated below take no account of Total Dissolved Solids (TDS) input originating from non-point sources.

MINIMUM DAILY FLOW REQUIREMENTS FOR ADEQUATE DISSOLVED OXYGEN
IN CUBIC FEET PER SECOND

Metropolitan Area	December January February	March April	May	June July August September	October November
Sioux City	1,800	1,350	1,800	3,000	1,350
Omaha	4,500	3,375	4,500	7,500	3,375
Kansas City	5,400	4,050	5,400	9,000	4,050

At Kansas City these values average 6,000 cfs on a yearly basis, a value which becomes important as a limit to ultimate depletions, discussed at length later in this report.

WATER SUPPLY

109. Numerous water intakes are located along the Missouri River within and below the system of reservoirs. These intakes are primarily for the purposes of municipal water supplies, thermal electric plant cooling purposes, and for irrigation supplies withdrawn directly from the Missouri River. Over the past years, problems have been associated with several of these intakes; however, the problems have been a matter of intake access to the water rather than insufficient water to supply requirements.

110. The minimum daily flow requirements established for water quality control could create operational problems at the municipal water supply intake at Yankton, South Dakota and municipal and electric plant intakes at numerous other locations along the Missouri River below the reservoir system. Similar to problems which have been experienced within the system, this is a matter of intake elevations or access to the available water supply. Evaluations are continuing by the Environmental Protection Agency in coordination with water plan operators and appropriate state agencies to determine the minimum stage and flow required for satisfactory operation at each intake.

RECREATION

111. During the past decade visitations at the six reservoirs have grown from five million in 1966 to 8-1/2 million in 1975. Growth was steady during the first eight years, reaching a peak of 9.4 million in 1973. The decline since that time has come at Lake Sharpe and Lake Oahe, down by one-fourth, and at Lake Sakakawea, down by one-sixth. At least a portion of this decline may be attributed to assertion by Indian tribes of jurisdiction over certain project lands and control of public access to them. This dispute, in common with the question of Indian water rights described in a later section,

is the subject of ongoing study and consultation with State authorities; and no recommended actions are contained in this report.

FISH AND WILDLIFE

112. Fish production and development in and below these projects are directly affected by reservoir levels and releases, particularly during the reproduction period. The Federal and State fish and wildlife agencies recognize that it is not possible to operate each reservoir each year for optimum fish management and have indicated that successful reproduction of a fish species one year out of four or five is adequate to maintain the fishery resource in a specific reservoir. Therefore, one or more reservoirs may be selected each year for emphasis in the enhancement of fish management. To the extent that inflows and regulation requirements for other purposes permit, the selected projects are regulated to improve the fishery resource.

113. State fishery personnel want conditions suitable for the spawning of northern pike to be provided in all of the main stem reservoirs at appropriate intervals. This involves raising the reservoir levels to inundate shore line vegetation early in the spring, and regulating at or above these levels through spawning season. In Lake Sharpe, Lake Francis Case and Lewis and Clark lakes this can frequently be accomplished with little disruption of other project purposes. Provision of desirable levels of Lake Oahe for spawning activities will usually require the accumulation of a plains snow cover during the winter months, and moderate early spring runoff from the melting of this snow cover, if other system functions are not to be adversely affected. The normal distribution of inflows into Fort Peck Lake and Lake Sakakawea, together with high winter releases for power generation, causes a winter drawdown at these reservoirs. Spring inflow is generally too late to raise the reservoir levels above the vegetation line before the northern pike spawn. The major adverse effect upon power generation necessary for development of northern pike spawning habitat in these reservoirs has precluded

operation of these two upstream projects for pike spawning.

114. Another area of increasing concern to fisheries interests is the propagation of forage fish upon which game fish species depend. Since many forage fish spawn later in the season than northern pike, a stationary or rising pool level extending through June is desirable. Such an operation is usually compatible with normal operation at Fort Peck and Garrison, and can often be accommodated with relative ease during years of high water supply at Oahe and Fort Randall. During years of deficient supply or abnormal distribution of the supply, such an operation would not be possible at one or more of the main stem projects.

115. Federal wildlife management on main stem reservoirs centers on the Charles M. Russell Wildlife Range, Audubon, and Pocasse National Wildlife Refuges established on Fort Peck, Lake Sakakawea and Lake Oahe. In addition, there are many acres managed by State agencies. Under this intensive management, wildlife production has been substantial. Large numbers of migrating waterfowl use the reservoirs in the fall until time of freeze-up. Canada geese and mallards winter on the open water below dams, at nearby refuge areas, and on open river reaches between Yankton and Sioux City.

Environmental Setting

116. A conventional treatment of the environmental setting would be to present in this section conditions as they now exist, with analysis in a separate and subsequent section of future conditions to be expected in the absence of any proposed Federal actions. The difficulty posed by this approach lies in the dynamic nature of the Missouri itself. Throughout time the river has continued to work upon its bed and its valley, building here, tearing down there. Change continues to be its motif, but since construction of the main stem reservoirs, the very nature of the changes has changed. To illustrate the present state of flux, comparisons with the future

are necessary. Consequently, this section will discuss not only the existing situation but also the near future conditions under such categories as physical setting, vegetation, etc.

117. Also essential to any such discussion is some perspective regarding the significance to the environment of the changes now operating. It is an easy and seemingly direct effort, for example, to develop a numerical tabulation showing average yearly acreages lost to various reaches of the river. So stated, the change might seem insignificantly small. The factors weighing against this conclusion are two-fold. First, the effects are cumulative, this year's loss, however small, is added to last year's in an irreversible process. Second, is the non-existence of an "average annual loss" as a physical reality. Based upon the concept of average annual losses, one might calculate that it would take 500 years or more to accomplish the loss of all the crop and woodland in an open river reach. In actuality, this transformation will result in the loss of one small increment of irreplacable habitat, at times unique and significant, to the gain of one small increment of aquatic or semi-aquatic habitat.

LAND AND WATER

118. Continuous bank stabilization on the Missouri River ends at Ponca, Nebraska, river mile 753. From this point to the upper end of the study area, the river channel, in large measure, is free to meander about the flood plain. A notable exception is the reach from Garrison Dam to Lake Oahe, where bank protection works authorized by Congress in 1963 have been completed in seven areas and are under construction in four more. Their total extent will be 30 miles. Along the uncontrolled reaches, the area between the high banks is occupied by normal river channel, sand bars, marsh areas and islands. Except for the area above Fort Peck, flooding over the tops of the high banks has been virtually eliminated by

reservoir regulation. Flooding beyond the normal river channel to inundate substantial areas of the bars occurs only in occasional years.

119. With the exception of rather infrequent rock sills or "controls" the river channel lies in a sandy bed. Since closure of the main stem dams, this channel has experienced continuing degradation, i.e., lowering of the bed, in the 10 to 15 mile reach below each dam.

120. As the normal river channel degrades, it also meanders between high banks. It is split into multiple channels by sand bars and islands. In a continuation of typical alluvial channel processes, material eroded from the high banks and from sand bars at one location is deposited to build new bars downstream. As a result of the on-going erosion and bar building processes, the location of the normal flow channel is not static. Over the years valley lands adjacent to high banks are converted to river channel, sand bars, or marshes. Islands give way to the channel, and main channels fill in or become inactive chutes while secondary channels open up to become main channels.

121. Studies based upon comparison of aerial photographs taken over intervals of twenty to thirty years indicate the following losses of flood plain lands from Fort Peck Dam to the lower end of the study area.

River Reach	Miles of Open River	Estimated Future Losses Acres/Year	Acres/Mile/Year
Fort Peck to Garrison	190	130	0.7
Garrison to Oahe	83	75	0.9
Oahe to Big Bend	5	2	0.4
Big Bend to Fort Randall	0	-	-
Fort Randall to Niobrara	36	30	0.8
Gavins Point to Ponca	58	200	3.4

122. Sand bars lie 10 to 15 feet below the tops of the high banks.

Bar surfaces range from bare sand, to areas vegetated by annuals and seedling willows and cottonwoods, to a more mature vegetative successional stand. The successional stage depends on the elevation of the bar above the normal range of water levels and how recently the bar was deposited. All bar areas between high banks are potentially subject to being destroyed by the shifting channel, only to be replaced by new deposition-created bars at other locations. This process will eliminate existing vegetation and the successional cycle will begin again.

123. Islands, by contrast, are areas about as high as the high banks, but separated from the high banks by river channels and inactive chutes. High bank erosion on the islands is a continuing process. In the absence of stabilization measures aimed specifically at their protection, the remaining island areas will ultimately be lost, to be replaced by sand bars, marshes and water.

124. In the case of the valley lands, too, the processes of high bank erosion and land building are not in balance. In the river prior to the construction and operation of the reservoirs, there was balance over the years between the destruction of the valley lands by erosion of the high banks and the building of new valley lands by sediment deposited during floods. Operation of the reservoir system has eliminated both the floods and the sediment deposition that were essential for the flood plain land building process. On the other hand, the erosion of high banks continues, although at a reduced rate. Consequently, erosion of the high banks results in a permanent net loss of high flood plain lands that will never be replaced in the valley as was the situation in the era before the reservoirs. High valley lands are being converted to sand bar areas and the width between high banks continues to widen. This process, unless halted, will eventually transform the present river into a wide area of sand bars and channels, occupying most of the width between bluffs with, however, little alteration in the overall dimensions of the existing

river channel.

125. The levels in the Missouri River today are highly regulated by the main stem reservoirs. Although widely varying flows are received from major right-bank tributaries - the Yellowstone, Little Missouri, Knife, Heart, Cannonball, Grand, Moreau, Cheyenne, Bad, White, and Niobrara - only the Knife, which enters the Missouri 72 miles above the Oahe headwaters, affects more than a dozen miles of open river. The result is that the major fluctuations of the pre-reservoir era, the huge flood peaks and the occasionally, nearly dry streambed, are absorbed by the reservoirs, and fluctuations observable today have in large measure been created by man.

126. The effects of this regulation upon the river flows are of two sorts: the short-term hourly fluctuation associated with operation of the hydro-power plants in meeting their daily loads, and long-term monthly and seasonal changes in flow level to accommodate multiple-purpose operating objectives. The short-term effects are limited in space as well as in time. While river stages immediately below Fort Peck may fluctuate as much as six feet in a day, distance has dampened the fluctuation to one foot 30 miles downstream. Comparable values at Garrison and Fort Randall are 11 feet reducing to three feet.

127. Prior to construction of the reservoirs, the typical regime along the Missouri was a low level of flow during the winter, increasing with the melt of plains snow in March and April, mountain snow in May and June and occasional widespread rains in the early summer. This peak season was followed by a decline during the hot, dry late summer and fall, to another winter low. Regulation of the lower four reservoirs to meet the requirements of flood control and navigation conform, in general, to this pattern with releases during the navigation season (mid-March to mid-November) running at least double the non-navigation rates of 6,000 to 15,000 cfs.

To help balance power generation, Fort Peck and Garrison are now operated with winter flows averaging nearly as large as, or even larger than summer flows, depending upon the water supply. Typically, the stage variations associated with seasonal regulation range from 5 to 10 feet.

128. Another change at work on the river is a continuing growth in depletions, a long-term reduction in average flow. The rate and the limit of this growth will assuredly be influenced by Federal and State action and by action of the Indian Tribes, as well as private individuals. The subject is discussed at some length in Section C of this report where, among other consequences of flow reduction, probable effects upon the environmental setting are projected.

VEGETATION

129. The entire area of the Missouri River drainage basin lies in a temperate grassland biome. Most of the basin falls in the mid-grass prairie region with dominant native vegetative species such as western wheatgrass, green needlegrass, side oats grama, needle-and-thread grass, and June grass. The remainder is located in the tall grass prairie dominated by big bluestem, Indian grass, switch grass, little bluestem, and sandreedgrass. The western portion of the study reach is in the short-grass prairie originally dominated by buffalo grass and blue grama. These regional variants are not homogeneous vegetation belts, but rather all three variants are mosaics of all three prairie types.

130. Zonal soils with average slope in the region of Fort Peck are dominated by western wheatgrass, blue grama, and needle-and-thread grass. Other important components are blue bunch wheatgrass, little bluestem, pasture sagebrush, threadleaved sedge, match brush, June grass, blazing star, plains muhly, sandburg bluegrass, sand dropseed, and green needlegrass. This is more xeric vegetative unit than that found to the east around Lake Sakakawea. West of Fort Peck where

more soil moisture is available in breaks due to edaphic and/or topographic factors, grassland gives way to trees. The dominant species of this community outlying from the Rocky Mountains are nine bark, ponderosa pine, quaking aspen, rocky mountain juniper, big sagebrush, and bluebunch wheatgrass.

131. Southwest of the Fort Peck area is a plant community of medium dense to open forests of low to medium tall evergreen trees with fairly open ground cover of grasses. The dominant species in the area is ponderosa pine. Other components are western wheatgrass, blue grama, and needle-and-thread grass. The same species that are dominant in the grassland along the Missouri River above and below Fort Peck, along the Yellowstone River, and along the Missouri River tributaries in the region are present in the northern flood plain forest community. The dominant tree species of this flood plain forest community are cottonwood, black willow, and American elm. Many of the species found lower down the valley do not appear this far north and there are fewer total species in this upper reach. Other important species (along the length of the Missouri) are box elder, virgin's bower, American ash, green ash, Virginia creeper, poison ivy, peachleaved willow, sandbar willow, and greenbriar. Along the middle and lower river reaches below Fort Peck where the soils are not heavy clays, the forest extends up into the Missouri River breaks. In these extensions the more xeric tree species such as green ash and American elm have greater coverage values while species like cottonwood, the seeds of which germinate and start along the shores of ponds or lakes, are almost completely eliminated.

132. From above the Lake Sakakawea area down past Lake Oahe and Pierre, South Dakota, to the vicinity of Chamberlain, South Dakota, zonal soils of average slope are dominated by western wheatgrass, blue grama, needle-and-thread grass, and green needlegrass. Other important components are slender wheatgrass, pussytoes, pasture sagebrush, white sage, white aster, purple-cone-flower, sedge, June

grass, bluebells, Indian ricegrass, beard tongue, little bluestem, silky wormwood, blazing star, silver-leaved scurf pea, goldenrod, and porcupine grass. There are, of course, wide variations in this large area. Much of this area has been greatly disturbed by man.

133. Between Garrison Dam and the headwaters of Lake Oahe, there are some portions of the Missouri River which are still in a natural state. The flood plain forest overstory in this region is composed of six dominant, deciduous species: cottonwood, peach-leaved willow, green ash, box elder, American elm, and bur oak. Important undergrowth species include various woody vines such as climbing bittersweet, western virgin's bower, wild grape, poison ivy and Virginia creeper. Also comprising the understory are different herbs and forbs like Kentucky bluegrass, false Solomon's seal, fringed loosestrife, western wild rose, and various sedges.

134. Along the upper portion of Lake Oahe, downstream of Bismarck, North Dakota, the uplands are dominated by a mosaic of herbaceous and low-growing shrubby vegetation of the steppe and shrub-steppe type. Steppe vegetation is dominated primarily by grasses though in places throughout the vegetative mosaic the dominance shifts to forbs and shrubs. There are several dominant grasses of the upland ecosystems. Western wheatgrass and green needlegrass are dominant over much of the area. Needle-and-thread grass, and sandreed grass are abundant on lighter soils, and little bluestem occurs on the steep, more highly eroded hillsides. Other grasses that occur in this community are side oats grama, sand dropseed, and three awn. Viewing the landscape more broadly, a mosaic of vegetative types responding to topography, exposure, and soils can be seen. The shrub snowberry often forms clones several yards across. This steppe vegetation is a diverse stable community which has evolved over thousands of years and, given freedom from excessive disturbance, continues to perpetuate itself. Shrub-steppe vegetation is that dominated by shrubs with an undergrowth of herbaceous species. It

occurs primarily on the west side of the lake and is dominated by silver sage with many of the same herbaceous species occurring under the silver sage that occur on the east side of the lake.

135. From Chamberlain to Yankton, South Dakota, big bluestem, western wheatgrass, and porcupine grass are the dominant native grassland species. Other component species are much the same as above Chamberlain. This is a dense, medium tall to tall grassland.

136. From Yankton, South Dakota to Sioux City, Iowa, the grassland is a tall-grass prairie with a dense vegetation of tall grasses and many forbs. This is a radically different community dominated by big bluestem, little bluestem, switch grass, and Indian grass.

137. Several species of grasses found established throughout the project reach are introduced for agriculture purposes, especially grazing. These grasses include creeping foxtail, tall wheatgrass, smooth bromegrass, crested wheatgrass, intermediate wheatgrass, Kentucky bluegrass, and Canada bluegrass.

138. Cultivated crops are also an important part of the existing vegetative setting. Major crops grown in the main stem region include alfalfa, corn, wheat, barley, and soybeans. Croplands comprise from half to three-fourths of the land use on the flood plain, with the higher proportions found in the lower reaches.

139. There are no threatened or endangered species of plants found along the main stem reach that are listed in the "Report on Endangered and Threatened Plant Species of the United States" compiled by the Secretary of the Smithsonian Institution, 1975.

140. The continuing process of conversion from high bank and island to low bank and channel will be an acreage reduction primarily in crop and woodlands. As previously noted, cropland constitutes at

least half of the flood plain land use, although a band often several hundred feet wide immediately adjacent to the river contains a higher proportion of woods than cropland. For each acre of flood plain lost, then, a quarter to a half an acre of woodland and three-quarters to half an acre of cropland will be supplanted by sand bar and marsh areas exhibiting various successional stages. These stages will range from rushes, sedges and cattails to willows and seedling cottonwoods. The proximity of sand bar and other low bank lands to permanent ground water, is expected to inhibit growth of cottonwoods to maturity and possibly beyond the sapling stage. The more xeric adopted flood plain trees and perennial grasses and forbs will also be constrained from growing on these bars and low lands. A relatively minor amount of savannah and grassland will undergo similar conversion.

FISH

141. The following paragraphs discuss the fish fauna and the population trends of the Missouri River reach between Three Forks, Montana, and Sioux City, Iowa. No attempt has been made to explain the distribution and the presence or absence of various species which may represent isolated populations or sampling artifacts.

142. Several fishes are mentioned in this report which are not residents of the Missouri River. However, they do inhabit various tributaries and hence may be found in the river although this would represent an accidental situation as opposed to a natural situation.

143. Many fish species are found along the entire main stem reach of the Missouri River. These species are: shovelnose sturgeon, paddlefish, northern pike, goldeye, European carp, flathead chub, fathead minnow, blue sucker, bigmouth buffalo, smallmouth buffalo, river carpsucker, white sucker, black bullhead, channel catfish, stonecat, burbot, black crappie, walleye, sauger, freshwater drum, emerald shiner, longnose dace, brassy minnow, silvery minnow, northern redhorse, largemouth bass, pumpkin-seed, bluegill, yellow perch and

white crappie. Many of these species have been introduced thus giving them a distribution through the entire system. One other species which should be included in this list is the pallid sturgeon which has been recommended for inclusion on the endangered species list.

144. A number of other species are mentioned in the literature as occurring in the Missouri River drainage, however, these have not been reported in the Missouri River itself.

145. Upstream from Fort Peck the previously listed species can be found with the addition of the American grayling which is found in some of the Missouri headwaters and thus may very rarely be found in the Missouri River. A number of other species may be found in the Fort Peck area, these are: mountain sucker, brook trout, coho, and kokanee salmon all but the first of which have been introduced.

146. Fort Peck Lake has a fishery composed of both game and rough fish. Several warm water species have been introduced into the Fort Peck lake area such as largemouth bass, bluegill and others. During 1973 a lack of suitable water levels resulted in little or no northern pike reproduction. This type of problem is also common to other main stem reservoirs. Since 1973 northern pike, walleye and sauger population appear to be increasing. In general, population of goldeye, freshwater drum, northern redhorse, smallmouth buffalo and emerald shiner have been increasing based upon current young-of-the-year seine surveys. Lake trout are apparently having their best year and natural reproduction is occurring. Coho and kokanee, both introduced, are dropping out as an important part of the Fort Peck lake fishery. Perch, crappie and river carpsucker reproduction also appear to have decreased during 1973. No information on the status of the paddlefish is currently available except that they appear seasonally at Intake, Montana on the Yellowstone River and more recently at the mouth of the Tongue River, apparently in

sufficient numbers and age composition to presuppose viable populations. Paddlefish are also taken frequently in the dredge cuts below Fort Peck Dam; whether reproduction occurs in the Missouri River between Fort Peck and Lake Sakakawea is unknown.

147. A number of other species first appear in the Fort Peck region but are also found in one or more of the downstream reaches; these species are: rainbow trout, brown trout, lake chub, longnose sucker, Iowa darter and the brook stickleback.

148. The quillback carpsucker and pearl dace are reported only in the Garrison area. A number of species not found in the Fort Peck region can be found in the Garrison area and southward, these include the golden shiner, tadpole madtom, shortnose gar, creek chub, sand shiner, the river shiner and the rainbow smelt which was introduced in 1973.

149. The sampling program in the Lake Sakakawea area is quite limited; thus data on existing populations are scarce. Several game species such as lake trout, northern pike, walleye and coho have been stocked; however, data are not available on the success of these stockings.

150. Five species, according to sampling data, are found only in Lake Oahe: sturgeon chub, blacknose dace, river shiner, silverband minnow and the spottail shiner which was introduced in 1973. Species found at Oahe and downstream include the blue catfish, white bass and flathead catfish.

151. In the Lake Oahe area the populations of several fish species have declined significantly. Between the years 1971-1973, inclusive, gill net sampling on a catch per unit effort basis showed declines for the following species: black crappie, 100 percent; carp, 45.9 percent; northern pike, 62.5 percent; smallmouth buffalo, 33.3 percent; walleye, 37.9 percent; white bass, 66.6 percent; and white

crappie, 66.6 percent. During the same time period, the following species showed significant gains: channel catfish, 244.4 percent; freshwater drum, 100 percent; goldeye, 27.3 percent; and river carpsucker, 15 percent. Data on the continuation or abatement of these trends remains to be investigated.

152. Hipple Lake, an important nursery area for gizzard shad, is located downstream from Oahe in Lake Sharpe. This area is important in that it produces a prey species which is important in the maintenance of walleye populations in the lake and in Oahe tailwaters. Two species, the longnose gar and the gizzard shad are found in the Lake Sharpe area and southward. Walleye in Lake Sharpe have shown a spectacular population increase, over 140 percent between 1964 and 1967. Data for 1973 as compared with 1964 data show the following population trends: carps, + 18 percent; bigmouth buffalo, -37 percent; shovelnose sturgeon, -65 percent; and northern pike, -100 percent.

153. In the Lake Francis Case area one species is picked up which has not been previously mentioned, the skipjack herring. The only addition to this species list that can be made by looking at the Lewis and Clark area is the silver chub. Data available for the Lake Francis Case area indicate that adult fish population have been generally on the decline since impoundment. The following fish population have all shown decreases on the basis of catch per unit effort between 1970 and 1973: bigmouth buffalo, 60 percent; carp, 22.2 percent; channel catfish, 23.4 percent; goldeye, 39.8 percent; northern pike, 50 percent; river carpsucker, 58.8 percent; sauger, 56.3 percent; shortnose gar, 77.8 percent; smallmouth buffalo, 47.1 percent; walleye, 30.5 percent; and white bass, 18.2 percent. During 1960, it has been estimated that 5,000 paddlefish were harvested in the headwaters areas of Francis Case Lake (Big Bend dam tailwaters). During 1971, less than 100 paddlefish were harvested in the Big Bend tailwaters. Paddlefish tagging operations

in 1969 and 1970 estimated an existing population in Lake Francis Case of about 31,000. Paddlefish in the lake are believed to be a relic population although this status has not been scientifically established. Current projections indicate a decline in downstream areas and extinction in the lake between the year 1990-2020. Two species have shown numerical increases between 1970 and 1973, the shovelnose sturgeon has increased 50 percent and the freshwater drum has shown an increase of 7.1 percent.

154. A very important spawning area is located between Fort Randall and Lewis and Clark lake near the state line between Nebraska and South Dakota. This area is important in that it is perhaps the only spawning area of significance in this stretch of the river and is believed to supply much of the fishery for the Missouri River between Fort Randall Dam and Lewis & Clark Lake as well as Lewis and Clark Lake. A Fish and Wildlife Service study infers that young fish from this spawning site may well contribute to the fish population in the Gavins Point Dam tailwaters and possibly farther downstream.

155. Fish populations in Lewis and Clark Lake have been studied since 1956, the first full year of impoundment. During the 1956-1973 period there has been a continual decline in fish abundance. According to the Fish and Wildlife Service the overall fish abundance declined 64 percent during the 1968-1972 period. On the basis of catch-per-unit effort data for the period 1965-1973 only three fish species have shown increasing abundance; white bass, 40.6 percent; yellow perch, 500 percent and the freshwater drum 215.2 percent. During this same period the following species have shown declines: channel catfish, 46.5 percent; white crappie, 78.9 percent; sauger and walleye, 11.1 percent and gizzard shad, 68.7 percent. Several factors such as siltation, loss of spawning area, fluctuating level and short retention period of water in the lake, and loss of young fish through the turbines and spillway contribute to the decline of fish abundance in this lake.

156. The continuing process of high bank (including islands) erosion should impact little, incrementally, on fish populations in the main stem lakes, although sediment deposition will influence the long-term fish populations. In the short-term, and possibly having a lasting impact, those fish species requiring stable, mature littoral habitat will continue to decline; these include northern pike, carp and smallmouth and bigmouth buffalo as well as a number of minnow species. State conservation agencies are, however, to some extent investigating possible remedies to this situation.

157. To the extent that the erosion process in the open river reaches creates stable, shallow water areas without fast current, there will be an increase in the numbers and diversity of the minnow family, the invertebrate community associated with this habitat type, and the producer organisms capable of colonizing in this habitat. The continuing population status of sauger, walleye, paddlefish, sturgeon, catfish and other species will be most dependent upon future river conditions as they relate to the spawning requirements of the fish. These conditions, in turn, are expected to be less sensitive to bank erosion than to stream depletions, which are discussed in the next section.

MAMMALS

158. A complete list of mammals that are found along the area of this study would include in excess of 75 species. Over one-third of this number can be found in good to excellent flood plain habitat along this entire reach of the river. Some more common members of this group are: the masked shrew, little brown bat, fox squirrel, racoon, striped skunk, coyote, eastern cottontail, deer mouse, white-footed mouse, muskrat, and prairie vole. Species which are not commonly seen because of their behavior or habitat requirements, but occur throughout the main stem system would include the following: silver-haired bat, hoary bat, mink, river otter, red fox, badger, meadow jumping mouse, western harvest mouse and beaver.

159. Three big game species can be found in the study area. The whitetail deer is the primary big game animal which utilizes the excellent habitat of the Missouri River flood plain. It shares the uplands with mule deer, which frequents the grassland or prairie communities. The prong-horn antelope, which also are endemic to grasslands, are found in the northwest quarter of the basin.

160. Certain mammal species are indigenous to small areas. Canadian lynx and snowshoe hare are confined to the more northern regions of the basin. Snowshow hares select the "willow bar" areas of the flood plain in the southern limits of its range. Gray squirrels are restricted to an area of mature flood plain forest between Lake Sakakawea and Bismarck, North Dakota. Eastern fox squirrel also occupy this area as well as the remainder of the study reach. The plains pocket gopher is reported from eastern South Dakota into northeastern Nebraska. Again this species is replaced by a similar one, the northern pocket gopher, in the remainder of the main stem system. Ord's Kangaroo rat and hispid pocket mouse are found in the zeric areas west and south of the Missouri River. The opposum is not able to adapt to the northern climate and as a result is found only in the southeastern region of the main stem system, downstream of Fort Randall dam.

161. Two mammal species are considered as endangered in this area. The northern rocky mountain wolf is found only in the extreme western portion of Montana. Its appearance in the study area is considered very unlikely. The black-footed ferret has been sighted in all four states of the study area. Little is known about this species, however, there does seem to be a relationship between black-footed ferrets and active prairie dog towns for food and shelter. Therefore, all prairie dog towns should be considered as possible ferret locations even if these "towns" occur in marginal habitat such as flood plains. Little is known about another critical species, the swift fox. Indications are that this species selects areas suitable for a

year-round den site and abundant prey species, usually in an open grassland community.

162. On-going changes in land form are felt in turn by the mammalian species. Habitat change will reduce opportunities for the mature flood plain forest species such as fox and grey squirrels, eastern cottontail, and most burrowing small mammals while favoring those mammals which inhabitat marsh and willow bar habitat. This group consisting mostly of aquatic fur bearers such as beaver, muskrat, and mink would be expected to increase in population. Those mammal species whose ranges encompass several habitat types, including mature flood plains, will also be selected against due to its habitat loss. Some numbers of this group are white-tailed deer, red fox and striped skunk.

BIRDS

163. Over 250 species of birds can be found in the main stem region of the Missouri River if both migrants and nesting species are counted. Well over 60 percent of the number are found to nest in one or more areas of the main stem region.

164. In considering these species, a number of them deserve special mention since they are aesthetically important in an area which provides habitat for nesting, feeding, or wintering; are listed as threatened or endangered species by the U. S. Department of Interior or are recommended for inclusion to this list.

165. The American peregrine falcon, an endangered species, has been known to occur in the Fort Peck area. This species is primarily a migrant in this location, however, during the 1969 and 1970 nesting season one aerie was reported in Montana. This aerie had adult falcons present, however, there was no mention of young.

166. Two other very rare and endangered species use a portion of

the study area as a migratory route. These species are the whooping crane and the Eskimo curlew. The last sighting of an eskimo curlew occurred in the early 1960's. The whooping crane flies over a segment of the main stem region during its yearly migration. Since it is a migrant, it may occasionally use main stem areas as feeding and resting areas.

167. Northern bald eagles and golden eagles make use of the main stem region for nesting, as a wintering ground, and as a major migratory route north and south. Especially heavy use is made of the Karl Mundt Eagle Refuge, below Fort Randall dam. As many as 200 eagles congregate in this area during the November-February period. The eagles principal food is fish which during the winter are readily available in the project tailwaters and ice-free river downstream. Use is also made of the mature flood plain forest as a shelter against winter storms.

168. The American osprey and prairie falcon are both found along the Missouri River. At this time they are not considered as endangered species, although their population levels are declining. Prairie falcons are a grassland bird and have been reported nesting in the Fort Peck and Lake Sakakawea areas. The osprey is a fish-eating raptor found along the entire main stem reach. A stable population of those species is contingent on the maintenance of suitable habitats.

169. Due to its alinement within the central fly way, the study reach of the Missouri is important to many species of migratory waterfowl. Several million ducks and geese use the main stem lakes, sand bars, islands, and open river as feeding and roosting grounds during their spring and fall migration. This is especially true in the river reach between Yankton, South Dakota and Sioux City, Iowa. In addition, dabbling ducks such as mallards, gadwall, pintail, blue-winged teal, and shoveler will use the area as a primary

nesting ground. Over 1.4 million pairs of these puddle ducks were indicated as nesting in the North Dakota prairie pothole region alone. Of this total almost one-third were reported to be nesting in an area closely associated with the Missouri River.

170. Pheasant and quail are the principal upland game bird using the mosaic of forest and agricultural lands on the flood plain. Prairie chickens, sharp-tailed grouse and turkey can be found on the upland prairie and breaks along the Missouri River.

171. Non-game birds make up the largest percentage of the bird fauna in the study area. This is a diverse group with each species having its own habitat requirement. Several large groupings can be defined however. A grassland group would include, horned larks, lark buntings, grasshopper sparrow, and western meadow larks. The wooded or flood plain community would include vireos, nuthatches, goldfinches, orioles, and many others. Along the river and its marshes the non-game bird community would consist of these and others; swamp sparrows, bitterns, herons, killdeer, plovers, yellow-headed and red-winged blackbirds. Two species are noteworthy due to their propensity to nest on sand bars or sandy areas along the river proper, These are the piping plover and the least tern.

172. The avian species composition in the Missouri River flood plain will also be affected by changes in land form. These changes will be of significance to those species which utilize the mature flood plain forest. This group consists mostly of passerines, although other orders would be affected. The most noteworthy of these are the eagles which would lose their primary winter roosting areas below main stem dams. The gallinaceous birds, principally pheasant and prairie grouse will suffer loss of crop and grazing lands adjacent to the river. Increases in numbers of puddle ducks and species diversity of shore and marsh bird populations is anticipated with an increase in low bank, marsh type habitat. Geese may not be

affected appreciably because there should be little change in the amount of open "plant-less" sand bars used by those birds as resting sites.

REPTILES AND AMPHIBIANS

173. The study reach has a full complement of herpetofauna, none of which is on the existing Federal threatened and endangered species list. Most of these species are associated with the Missouri River or its tributaries at some point in their life cycle. The ranges of many of these species is not clearly defined and a particular species may occur both in the flood plain and in the drier upland areas. The range will expand and contract in response to existing environmental conditions.

174. A number of species inhabit the entire study reach. These species are: snapping turtle, western painted turtle, western softshell turtle, plains gartersnake, resided gartersnake, king snake, bullsnake, milksnake, prairie rattlesnake, tiger salamander, plains spadefoot toad, rocky mountain toad, great plains toad, chorus frog and leopard frog.

175. Two species found in the study area are more predominant in the more northern and western reaches; these are the short-horned lizard and the boreal chorus frog.

176. Most species seem to prefer the more eastern and southern reaches of the study reach. Moving southward with the Missouri River from Fort Peck the eastern yellow-bellied racer and the western hognose snake first appear in the Sakakawea area, the smooth green snake and the smooth softshell turtle are encountered in the Oahe area, and the bullfrog can be collected in the southern reaches of the Lake Francis Case area.

177. The southeastern most part of the study reach, principally

the Lewis and Clark area is the richest in herpetofauna. In this reach a number of species are present that are not found in the basin upstream and include northern prairie lizard, six-lined racerunner, prairie ringneck snake, lined snake, cricket frog and the western chorus frog.

178. With an increase in development of aquatic and semi-aquatic habitat an increase is anticipated in population levels of those reptiles and amphibians which are dependent on this type of habitat, such as tiger salamanders, leopard frogs, and softshell turtle. Species which are restricted to more terrestrial environments such as the spadefoot toad or bullsnake will decline in numbers due to decreased amounts of habitat.

DISEASE VECTOR PROBLEMS

179. The principal vector problem that currently exists at several points along the main stem system concerns mosquitos. The increasing mosquito population can be traced to increased breeding areas being caused by hydrologic changes resulting from the operation of the main stem system. These areas are low lying waterlogged areas of shallow standing water which can produce enormous broods of mosquitos. These areas are closely correlated with water levels; i.e., "feather edge" flooding as opposed to moderately steep shorelines or shallow inundation of flat vegetated portions of shoreline or marsh area. The location of these sites is as follows:

Portions of the Buford-Trenton Irrigation District near the headwaters of Lake Sakakawea.

An area south of Bismarck, North Dakota near the headwaters of Lake Oahe.

The vicinity of Fort Pierre, South Dakota, five miles downstream from Oahe Dam and near the headwaters of Lake Sharpe.

Near Niobrara, Nebraska, in the headwater vicinity of Lewis and Clark Lake.

180. Present studies in the headwater area of Lewis and Clark Lake and the Niobrara area showed prolific production of Aedes, the flood-water mosquito and Culex, the encephalitis mosquito. In this area, continued siltation and the resultant increase in marshy and ponded habitat will likely result in an increasingly severe mosquito problem. During 1972, the State of Nebraska and the U. S. Army Corps of Engineers utilized aerial spraying to alleviate the problem. At present the State of Nebraska, U. S. Army Corps of Engineers, Department of Health, Education and Welfare as well as county and community representatives have developed a monitoring program and are formulating alternative control measures.

181. Increased marsh-like water areas caused by conversion of high bank lands to sand bars will provide more and more egg-laying habitat for permanent-water mosquitos such as Anopheles and Culex. This will be particularly true in the regulated river reach below Gavins Point dam. The changing river environment below the other dams may favor the mosquitos which deposit their eggs on moist soils with hatching of the eggs being stimulated by subsequent inundations. Continued waterlogging in the lakes' headwaters should enhance the population growth of, in the short term, the temporary-water breeders (Aedes & Psorophora) and, in the long term, the permanent-water breeders.

Descriptive Publications

182. In addition to the reports of survey scope already tabulated, a number of other studies and reports provided data of value in the present study.

- Report on Adequacy of Flows in the Missouri River, Missouri Basin Inter-Agency Committee, April 1951.
- Supplemental Report on Adequacy of Flows in the Missouri River, Missouri Basin Inter-Agency Committee, April 1959.
- The Missouri River Basin Comprehensive Framework Study, Missouri Basin Inter-Agency Committee, June 1969.

● Missouri River Main Stem Reservoir Operation Studies - Series 6-69, U. S. Army Engineer Division, Missouri River, Corps of Engineers, Omaha, Nebraska, 1969.

● Report on Modification of Operation of Lake Francis Case, South Dakota, U. S. Army Engineer Division, Missouri River, Corps of Engineers, Omaha, Nebraska, October 1972.

● Missouri River, South Dakota, Nebraska, North Dakota and Montana, Preliminary Study - Additional Hydro-power, Sverdrup and Parcel and Associates, Inc., June 1973.

● Missouri River Main Stem Reservoir Regulation Studies, Series 1-74, U. S. Army Engineer Division, Missouri River, Corps of Engineers, Omaha, Nebraska, 1974.

● Coal Development Alternatives, David D. Freudenthal, Peter Ricciardelli, and Michael N. York, Wyoming Department of Economic Planning and Development, December 1974.

● Effects of Coal Development in the Northern Great Plains, prepared by Northern Great Plains Resources Program, April 1975.

● Missouri River Basin Industrial Water Marketing; Hearings before the Subcommittee on Energy Research and Water Resources of the Committee on Interior and Insular Affairs, United States Senate, Ninety-Fourth Congress, First session, 1975.

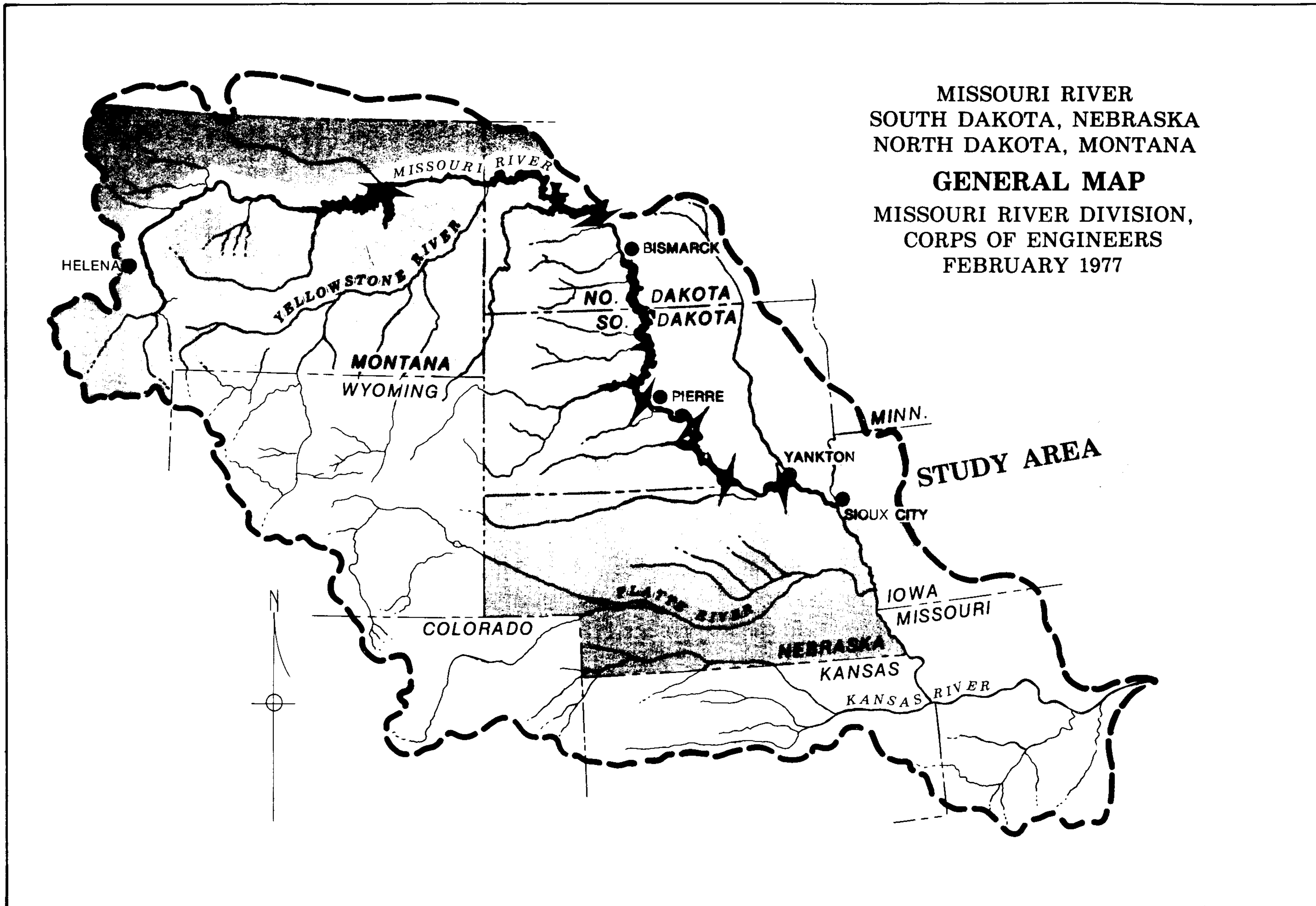
● Annual Operating Plan 1975-1976 and summary of Actual 1974-1975 Operations, Missouri River Main Stem Reservoirs, U. S. Army Engineer Division, Missouri River, Corps of Engineers, Omaha, Nebraska, August 1975.

● Missouri River Main Stem Reservoir Regulation Studies, Series 12-75, U. S. Army Engineer Division, Missouri River, Corps of Engineers, January 1976.

● Summary Report on Regulation of the Missouri River Main Stem Reservoir System to Control the 1975 Inflows; U. S. Army Engineer Division, Missouri River, Omaha, Nebraska, August 1975, revised and extended January 1976.

● Water and Related Land Resources in the Missouri River Basin - Present and Future Uses and Associated Problems and Issues,

Missouri River Basin Commission, Omaha, Nebraska, June 1976.


MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA
NORTH DAKOTA, MONTANA
GENERAL MAP
MISSOURI RIVER DIVISION,
CORPS OF ENGINEERS
FEBRUARY 1977
MISSOURI RIVER
HELENA
YELLOWSTONE RIVER
MONTANA
WYOMING
BISMARCK
NO. DAKOTA
SO. DAKOTA
PIERRE
MINN.
YANKTON
STUDY AREA
SIOUX CITY
IOWA
MISSOURI
PLATTE RIVER
COLORADO
NEBRASKA
KANSAS
KANSAS RIVER
N

SECTION C

PROBLEMS AND OPPORTUNITIES

PROBLEMS AND OPPORTUNITIES

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SECTION C.

PROBLEMS AND OPPORTUNITIES

1. One common thread is woven through all of the diverse Congressional actions which led to this report - the river itself. Some of its impacts upon the study area have been extolled as good things which must be preserved, some have been denounced as bad things which must be remedied. Some have been called both good and bad in accordance with the differing views of the beholders. Some of the study findings deal with problems left unresolved by the completion of the main-stem reservoirs -- created, in fact, by the very existence of that system. Some deal with opportunities to provide more or different services than are presently being delivered. And some are findings that a study element cannot be recommended for implementation.

Water Use

2. The outstanding opportunity available to the people of this area lies in the fashioning of a wise policy on how to garner future water resource benefits. In a nation recurrently warned of impending

crisis arising from widespread and chronic shortage of water, the Missouri River is very evidently a source of vast wealth, both tangible and intangible. This section will identify a number of views on who has the authority and whose choices are best suited to utilize that wealth, as well as some consequences of the various choices.

Authorization of Water Resource Development

3. The views of the U. S. Congress, as expressed by the 1944 Flood Control Act, which authorized the Pick-Sloan Plan, are detailed in supporting legislative documents.

4. House Document 475, the Pick Plan, described the purposes of the main stem reservoirs as follows:

> "In addition to providing flood-control benefits on the Missouri and Mississippi Rivers, the comprehensive plan would also provide for the most efficient utilization of the waters of the Missouri River Basin for all purposes, including irrigation, navigation, power, domestic and sanitary purposes, wildlife and recreation."

5. The Sloan Plan, voicing Bureau of Reclamation views in Senate Document 191, said,

> "All reservoirs included in the comprehensive plan, including Fort Peck, should be operated to obtain the maximum benefits in common for flood control, navigation, irrigation, power generation, and other water-conservation activities, including but not limited to, utilization for fish and wildlife preservation, recreation, pollution abatement, maintenance of surface and ground water levels, silt control, and domestic and industrial purposes."

Competing Water Uses

6. Although many elements of this study are vitally concerned with water use -- whether flow is diverted from the river or reserved for instream purposes -- this is not true in every case. The problems of bank erosion, waterlogging, and siltation may be expected to persist in some degree regardless of the trend in yearly flow; their analysis, therefore, is relatively insensitive to projections of demand for

Missouri River water. For the large part, however, the study must be founded upon an understanding of past evolution of water uses and an evaluation of possible future trends.

7. Competition for water may be of two sorts: between two or more purposes which divert water from the stream and fail to return part or all of it, i.e. "consumptive" uses, and between the sum of all consumptive uses and the "non-consumptive" or instream uses. In the long-term aggregate, non-consumptive uses are not competitive among themselves; during any given year, however, conflicts may arise over the timing, flow rate, or duration or reservoir releases and associated water levels in the reservoir.

8. An important addition to the 1944 Flood Control Act was Section 1b, the O'Mahoney-Millikin Amendment, which stated,

> "The use for navigation, in connection with the operation and maintenance of such works herein authorized for construction, of waters arising in States lying wholly or partly west of the ninety-eighth meridian shall be only such use as does not conflict with any beneficial consumptive use, present or future, in States lying wholly or partly west of the ninety-eighth meridian of such waters for domestic, municipal, stock water, irrigation, mining or industrial purposes."

9. Although non-consumptive uses other than navigation had been advocated in its legislative history, the 1944 Act was silent regarding the relative preference to be given such purposes as power generation, fish and wildlife preservation, recreation, pollution abatement, and maintenance of surface and ground water levels vis a vis beneficial consumptive use. Two decades later the competing claims to first importance are still being made; moreover, a growing awareness of the value of the water resource has led from a competition among uses to competition among jurisdictions. By whom and by what authority will future development of the Missouri River be directed?

Competing Jurisdictions

THE FEDERAL INTEREST

10. Federal authority to participate in water resources development rests initially upon the Constitution of the United States, as amplified and implemented by judicial decisions and a number of Congressional acts.

11. The Constitution. Water resources, per se, are not mentioned in the Constitution, but several basic clauses provide the source of authority for the Federal Government to develop and operate water resource programs.

12. The Commerce Clause vests in Congress the right to control navigable waters and is cited frequently as the authority for the Federal Government to engage in water resources development. Although the clause in theory can be exercised only when benefits of at least incidental magnitude accrue to navigation, the link is sometimes tenuous. In addition to the regulatory power which Congress, under the commerce clause, exercises over navigable waters, the judicial doctrine of navigational servitude declares that Federal jurisdiction is paramount and thus, in the exercise of the navigation power, water and certain other property may be taken without compensation.

13. The Property Clause which gives to Congress power "to make all needful Rules and Regulations respecting the Territory or other Property belonging to the United States" is the basis for Federal control of waters on Federal lands.

14. The Treaty Power enables the President, with advice and consent of the Senate, to make treaties which then stand on equal footing with acts of Congress. The treaty power plays an important role in the assertions of Indian water right claims discussed later in this report.

15. The General Welfare Power and the War Power both have the potential for managing water resources although the latter, as yet, has not been extensively used.

16. The Supremacy Clause declares the Constitution, and the laws and treaties of the United States to be the supreme law of the land, "anything in the Constitution or Laws of any State to the contrary notwithstanding."

17. Statutory Provisions. The Act of 1811 dealing with the navigable waters of the Louisiana Purchase and the first Rivers and Harbors legislation dating back to 1824, bespeak the early and continuing Federal interest in navigation. Indeed, the constitutionality of the O'Mahoney-Millikin Amendment referred to in an earlier paragraph has been subject to speculation - but never to test - in light of this interest.

18. The River and Harbor Act of 1899 established the Section 10 Permit program, requiring authorization by the Secretary of Army prior to obstructing, excavating from or depositing material in navigable waters. Seventy-three years later, evolving concern over quality of the Nation's waters culminated in the Federal Water Pollution Control Act Amendment of 1972, which now covers not only streams determined to be navigable but all the waters of the United States. Regulated activities include the discharge of pollutants into the waters of the United States, the discharge of any material dredged or excavated from such waters, or fills including land fills and backfills, dams, dikes, levees and bulkheads. Thus, the earliest non-consumptive use, has over the years become a tool for implementing one of the most recent concerns, water quality. Together with legislation directing planning consideration, fund sharing, or both in the fields of recreation, fish and wildlife and environmental policy, the 1972 legislation insures a Federal role in maintaining the quality of life. This role will be felt not only in the tailoring

of future Federal programs, but in the monitoring and regulation of State and private activities as well.

19. With recreation, fish and wildlife, water quality and environmental concerns thus itemized, hydropower generation is the only other non-consumptive use of major significance. Federal interest goes to the Act of 1906 which authorized the Secretary of Interior to produce and sell electric energy in connection with reclamation projects. Reference has already been made to H.D. 475 and S.D. 191, both of which specifically called for power generation as an element of the Pick-Sloan Plan.

20. Flood control is neither a consumptive nor a non-consumptive use of water; moreover, there has been no observable competition directed toward preempting the Federal role in this area. The Flood Control Act of 1936 established the nationwide policy that flood control is in the interest of the general welfare.

21. Federal interest in consumptive uses of water was documented in the O'Mahoney-Millikin Amendment (Section 1(b) of the 1944 Flood Control Act) already referred to. A number of other authorizing acts exist, both prior and subsequent to 1944; like the 1944 Act they too took advantage of the multiple-use concept to encourage non-consumptive functions as well, as shown in the following paragraphs.

22. The Reclamation Act of 1902, with coverage broadened to recognize multiple-purpose concepts by the Reclamation Project Act of 1939, enables the Bureau of Reclamation to plan and construct projects to serve irrigation, power generation, municipal and industrial uses, recreation, fish and wildlife enhancement, stream regulation, pollution control, and flood control. The Warren Act of 1911 permits the sale, on short-term contract, of surplus project water to nonproject users.

23. The Water Supply Act of 1958 (PL 85-500) broadened previous authority of the Secretaries of Interior and Army to include in Federal projects reservoir storage for present and anticipated future municipal and industrial water supply. Inclusion of such storage is dependent upon state or local assurance of repayment of the allocated cost and interest within the life of the project but not to exceed 50 years after first use for water supply.

24. The Secretary of Agriculture was directed by legislation in 1935 to establish the Soil Conservation Service with further emphasis on watershed protection in the 1936 and 1944 Flood Control Acts. The Watershed Protection and Flood Prevention Act of 1954 (PL 566) authorizes the Secretary of Agriculture to plan for an assist in financing projects for control and use of water in watersheds not exceeding 250,000 acres. Project purposes may include flood prevention, drainage, irrigation, water supply, streamflow regulation, fish and wildlife, recreation, and municipal and industrial water supply.

INDIAN CLAIMS TO WATER

25. A discussion of Indian water rights must begin with the Winters doctrine, which arose from a case originating in the Federal District Court for Montana and after twice being presented to the Circuit Court of Appeals, was finally decided by the United States Supreme Court in 1908. This was followed by another Montana case, Conrad Investment Co. decided by the Circuit Court also in 1908. These two decisions and a number of subsequent amplifications constitute the backbone of Indian water right claims. Although their applicability has been asserted throughout the West, it is noted that these landmark cases arose in the upper reaches of the Missouri basin, the general area later destined to contain the main stem dams.

26. The doctrine thus developed holds that where Indian tribes on organized reservations have, by treaty with the United States or by

executive order had water rights reserved on occupied land, the Tribe has a prior and paramount right to all waters so reserved, dating from the treaty or order. Moreover, if the need for water increases over time, the right to use this water increases also and is valid against all other claimants, except perhaps the United States. Such rights apply not only to lands historically occupied by a tribe and with a specified reservation of water rights, but also to Federal grants where reservations are established on lands which were not historically occupied.

27. Enunciation of this doctrine has led to active debate over the quantification of Indian rights. A number of studies made by non-Indian water use planners have assumed Indian entitlement to all the water which could be used on their lands for irrigation, stock-water and domestic use, while maintaining that commercial or industrial uses were never intended for reservation by case law. Indian spokesmen interpret more broadly the language of the Conrad court which refers to the Winters determination of "the paramount rights of the Indians of the Blackfoot Indian Reservation to the use of the waters of Birch Creek to the extent reasonably necessary for the purposes of irrigation and stock raising and domestic and other useful purposes." One other doctrine fundamental to the Indian position, is expressed in this exerpt from the Colorado Supreme Court: "To say ... that an appropriator from the main stream is subject to subsequent appropriators from its tributaries would be the overthrow of the entire doctrine ..." And the Ninth Circuit Court of Appeals added "it would be a novel rule of water law to limit either the riparian proprietor or the appropriator to waters which originated upon his lands or within the area of appropriation. Most streams in this portion of the country originate in the mountains and far from the lands to which their waters ultimately become appurtenant."

28. Given the broadest definition of water use and the broadest area from which it may be appropriated, the scope of ensuing claims

is not too difficult to anticipate. It is plainly stated in "Declaration of Indian Rights to the Natural Resources in the Northern Great Plains States." This document was prepared by the Member Tribes in the Native American Natural Resources Development Federation of the Northern Great Plains and submitted to the Northern Great Plains Resources Program in June 1974. The 26 member tribes, residing in Montana, Wyoming, North Dakota, South Dakota and Nebraska, on page 1 of the report, declare:

> "The Indian tribes of the five states do hereby give notice to the world that they will maintain their ownership to the priceless natural resources which are geographically and legally related to their reservations. Indian tribes and people, both jointly and severally, have declared and the courts have sustained that the American Indian tribes of the Northern Great Plains have the prior and paramount rights to the waters of all rivers, streams, or other bodies of water, including all tributaries thereto, which flow through, arise upon, underlie or border upon their reservations. These prior and paramount rights would extend to all waters that may now or in the future be artificially augmented or created by weather modification, by desalination or presently unusable water supplies, by production of water supplies as a by-product of geothermal power development, or by any other scientific or other type of means within the respective reservations in the Northern Great Plains area.
>
> In view of the tribes' prior and paramount rights to all the waters to which they are geographically related, it is self-evident that any major diversion of said waters for any purpose would constitute an encroachment upon Indian water rights. All Federal agents or agencies, including but not limited to the Bureau of Reclamation, Corps of Engineers, states, persons, parties or organizations are, therefore, put on notice that any diversion or use of such tribal waters shall be at their own risk."

29. Evidently, the issues thus joined are more complex than those

addressed in the Winters, Conrad, and allied cases. Those issues were raised by the United States as trustee for the Indian tribes, in opposition to claims of States or private parties. The sweeping contentions set out above challenge the sovereign power of the United States itself and are likely to be settled only after protracted further judicial and perhaps legislative effort.

STATE INTERESTS

30. In view of the sweeping Indian claims just recited, and the massive Federal history of Constitutional and statutory authority in support of water resource management, the status of the Basin States might at first blush appear to be one of suppliants hoping to secure some overlooked droplet. Such a conclusion lacks total certainty.

31. The Secretary of Interior, under Section 8 of the Reclamation Act of 1902, is directed to "proceed in conformity" with State water law. In a 1975 case presently under appeal, The United States of America vs The State of California et al, the Federal District Court ruled, "that the United States can appropriate unappropriated waters necessary for use in any Federal reclamation project with the State of California, without the necessity of applying to the California State Water Resources Control Board." Furthermore, "when the United States chooses as a matter of comity to submit applications to the ... Board, that Board must grant such applications if unappropriated waters are available." The full impact of this ruling is yet to be ascertained. The Corps of Engineers involvement in water supply activities is primarily under terms of the 1958 Water Supply Act. This Act does not provide for the sale of water but rather provides contractual allocation of reservoir storage only to parties holding State water rights. The Soil Conservation Service goes one further step, requiring a local entity to take title to the structure.

32. In the several western states use of decreed rights has changed over the years; in order to adjudicate water use an occasional general

review and update may be necessary. At times the United States has refused to participate in such proceedings, standing upon its sovereign immunity. The McCarran Amendment enacted by Congress as a rider to a 1952 appropriation bill, was an effort to ensure Federal participation in State general adjudication suits. In the case of the United States vs Eagle County, the United States Supreme Court held the McCarran Amendment to be an all-inclusive statutory provision that subjects to general adjudication in state proceedings all rights of the United States to water within a particular state's jurisdiction regardless of how they were acquired. This struck down the Federal contention that the amendment applied only to water rights acquired under state law and not to the Government's reserved rights.

33. Aside from the maze of legal uncertainties, the political clime seems pointed toward a lessening degree of Federal participation in water resource development. Arrangements such as that between EPA and the states on water quality standards are being considered as a modification of the Section 404 program to regulate dredging and filling, and there have been indications of Federal willingness to delegate management of consumptive uses as well. This Federal emphasis on the role of non-Federal authority has been accompanied by a companion Federal emphasis on non-Federal funding.

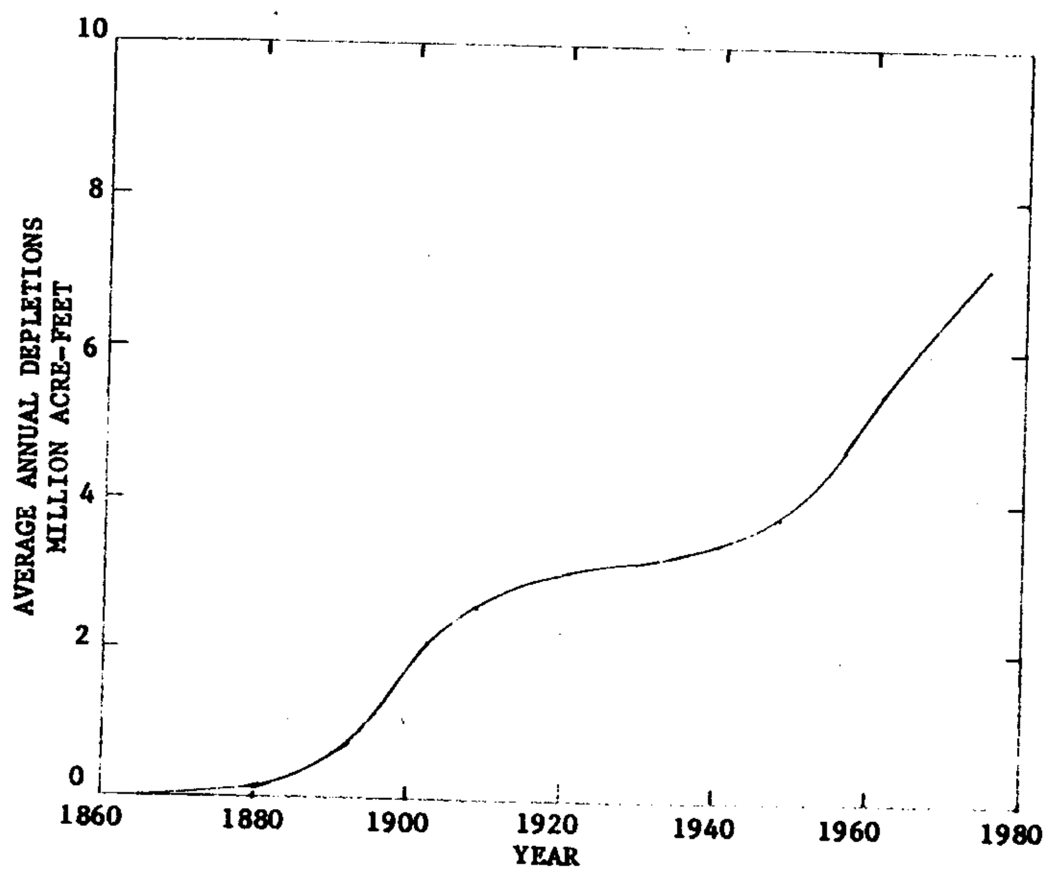
The Water Supply — Past and Present

34. Prior to 1865, streamflow in the Missouri River was put to little use except for transportation. At about that time, the early settlers and homesteaders, their numbers swollen by uprooted Civil War Survivors, started irrigation and mining ventures and began filing for water-use permits in substantial numbers. Some additional irrigation development was induced by establishment of Indian reservations.

35. By 1898, Missouri River flows at Sioux City had been depleted

an estimated average of about 1.5 million acre-feet per year. Beginning with that year a "reconstituted" flow record has been compiled on a monthly basis, utilizing gaging records where available, high water marks and readings taken at old military posts. Streamflow records, of course, reflect the constantly changing levels of water resources development and streamflow depletion. Growth of average annual depletions, including reservoir evaporation, is shown in Figure C-1. These reductions in flow reflect not only withdrawals from the Missouri itself, but depletions of upstream tributaries as well.

FIGURE C-1 GROWTH OF STREAMFLOW DEPLETIONS AT SIOUX CITY



36. To be useful as an accurate measure of surface water-supply availability, historic streamflow data must be adjusted to a common level of water resources development and water use and a corresponding common level of streamflow depletion.

37. The year 1949 has become one common base level for studies utilizing Missouri River flows. Stemming from the Report on the Adequacy of Flows in the Missouri River, published by the Missouri Basin Interagency Committee in 1951, flows prior and subsequent to 1949, have been reduced or increased to reflect that level of depletions. Figure C-2 shows the record of annual flow volumes at Sioux City, Iowa, from 1898 to 1975 reflecting 1949 depletion levels, which amount to an average of 3.8 million acre-feet per year.

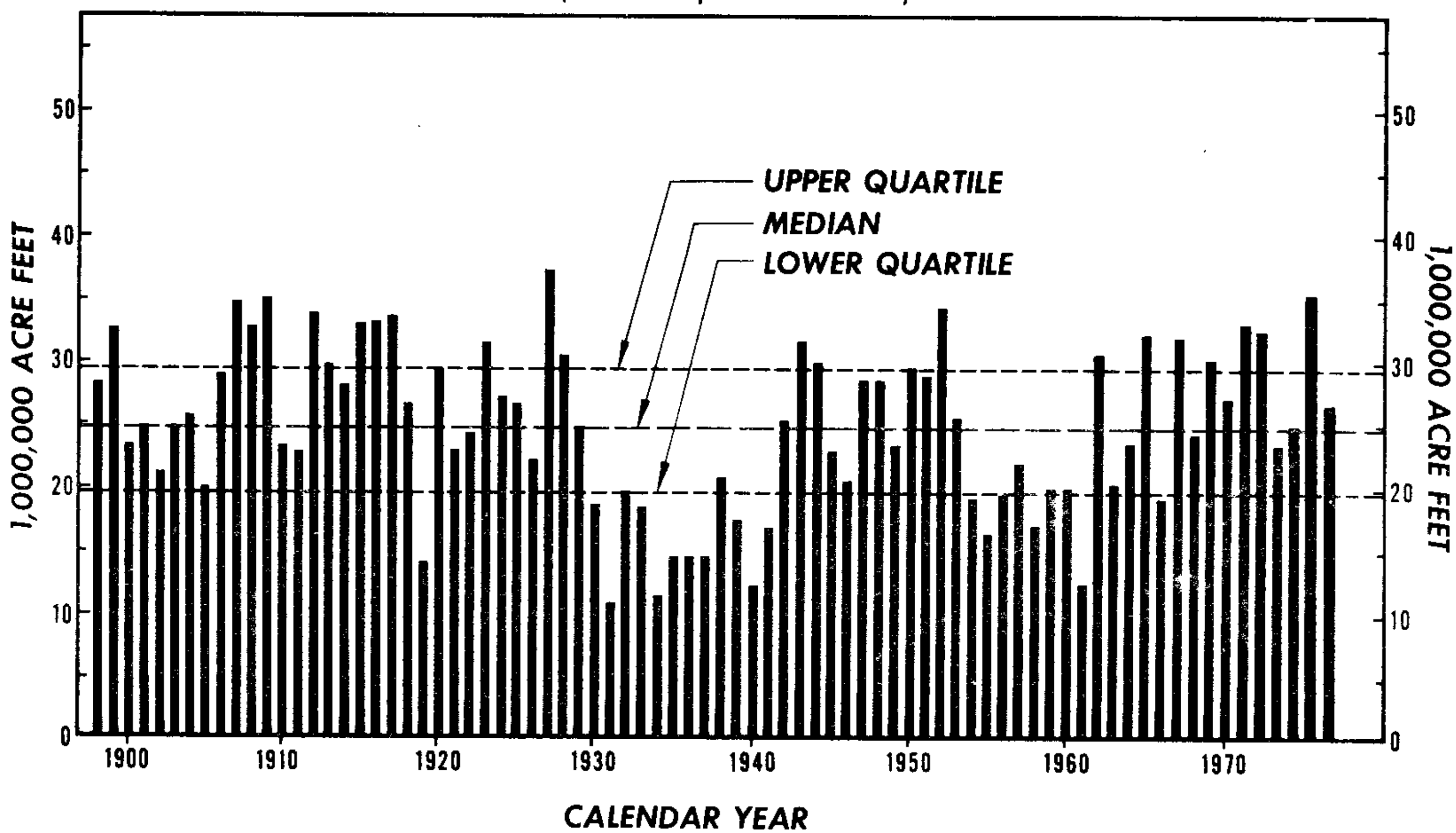
38. A second common base is the 1970 level of depletions. This level of consumptive use underlies analyses developed for the Missouri River Basin Comprehensive Framework Study and numerous subsequent operation studies conducted by the Corps of Engineers, many in collaboration with the Bureau of Reclamation. Among these are studies run in 1970, 1974 and 1976 to estimate projected impacts of industrial development of western coal fields, in addition to other uses. Measured against the predevelopment level of 28.5 million acre-feet, the average annual flow under 1970 conditions is depleted by 6.5 million acre-feet, of which one-fourth is evaporation from the six main stem reservoirs.

Alternative Future Uses

39. The scope of this study **originally included efforts to identify** those water uses which would best promote the orderly, efficient, and timely utilization of the basin's resources. Such an analysis would recognize the competition for available water supplies, the economic and environmental effects, costing and marketing policies and water rights.

Fig. C-2 **ANNUAL WATER SUPPLY MISSOURI RIVER AT SIOUX CITY**

(1949 Depletion Level)



40. In common with all other phases of the study, the efforts described above were to be coordinated with the affected states, appropriate Federal agencies, and with the Missouri River Basin Commission. The Commission, on which the ten basin states are represented, served as a forum for discussing the significant issues and problems being addressed by the study. The active assistance, advice, and participation of all interested entities was solicited, especially the upper basin states where the main stem reservoir system is located. Although general input to this investigation has been achieved for the system-related problems and hydro-power phases of the study, such has not been the case concerning competing water uses and possible system modifications for best meeting these demands. The states will not support nor participate in such studies at this time. The upper basin states in particular feel strongly that to quantify specific uses is premature and should not be undertaken until after state water plans have been updated and state water needs have been assessed.

41. This position has caused a change in the report's scope. Studies are complete on the capability of the reservoir system to supply water for today's uses and for other potential future demands. These studies provide a baseline from which states, the River Basin Commission, and other affected interests can assess general impacts of future actions. There are not, however, any recommendations dealing with priorities of water use -- **only an outline of the analyses** which will be required to address the physical, economic, environmental, social, and legal and institutional issues at some future time.

CRITERIA

42. Water resource specialists have exhibited in times past an almost unfailing tendency to overestimate the rate of growth in Missouri River depletions. The clouded crystal ball is certainly no easier to read today than it was in years past; as a result an effort has been made in the following paragraphs to display a range of impacts

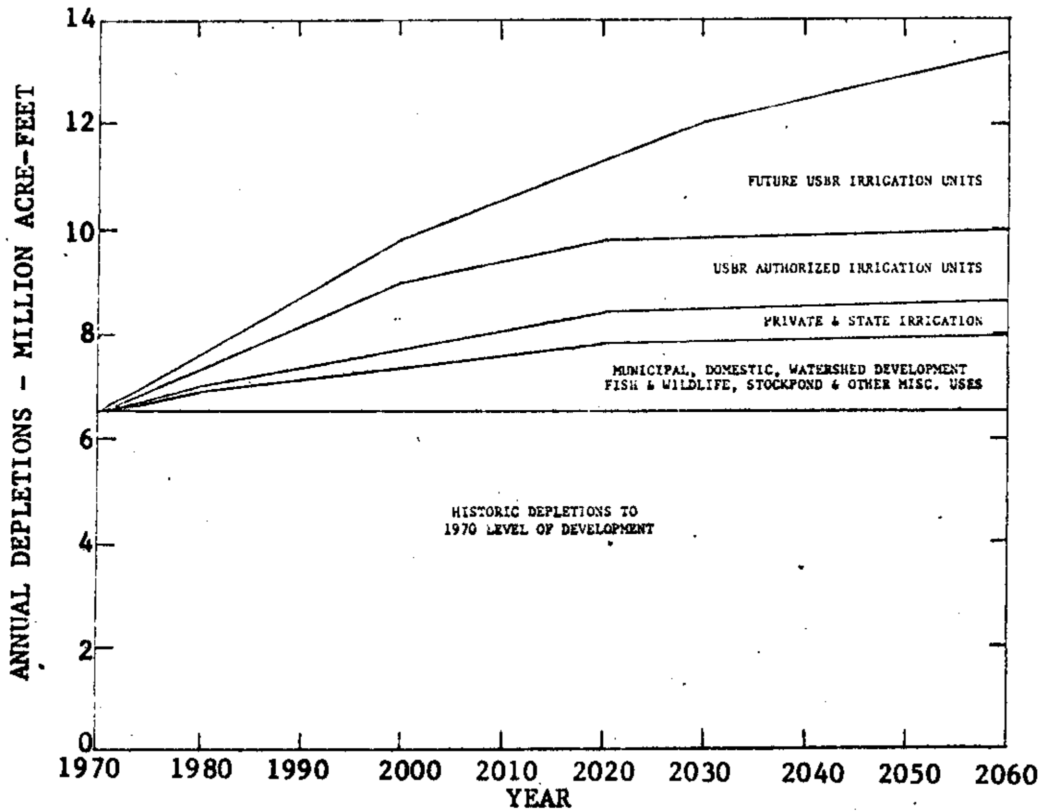
associated with a range of depletions -- a sensitivity analysis for those functions related in some fashion to flows in the Missouri River.

43. Projected Depletions. Concurrently with the mushrooming interest of energy companies in developing coal resources of the upper basin there began to be heard pronouncements that there is just not enough water to go around. In response to these frequently heard views, the Assistant Secretaries of Interior and Army appointed a regional Ad Hoc Committee to examine the issues involved in industrial water marketing from the six main stem reservoirs. This Ad Hoc Committee on Water Marketing was formed in December 1973, under the Chairmanship of John W. Neuberger, Chairman of the MRBC, with representation from Army, Interior and the basin States.

44. Through its efforts were developed the projections of future depletions presented on July 18, 1975 by the Department of Interior to the Subcommittee on Energy Research and Water Resources of the Senate Committee on Interior and Insular Affairs, and illustrated in Figure C-3. These depletions are essentially unchanged from the 1969 estimates made for use in the Missouri River Basin Comprehensive Framework Study with three exceptions -

- The Framework Study projected the existence in 1970 of several projects which have not been constructed. Depletions for the larger units were restored to streamflow, but the **results still overstated depletions in the amount of several thousands of acre-feet annually.**
- "Ultimate" depletions above Sioux City were reduced from 15.3 million acre-feet per year in the Framework to 13.3 million acre-feet per year to correct for the earlier projections of irrigation unsupported by either a surface or groundwater supply.
- Attainment of the ultimate level was shifted from the year 2020 to 2060.

FIGURE C-3 PROJECTED GROWTH
AVERAGE ANNUAL DEPLETIONS*
MISSOURI RIVER AT SIOUX CITY



*** Excluding estimates of industrial use**

45. Diversions for increasing surface water irrigation are measured or compiled routinely, enabling ready confirmation of that component of use. Depletions for fish and wildlife, stock ponds, watershed treatment and ground water irrigation are much more difficult to verify; there is a tendency to assume their use is developing on schedule until a subsequent detailed water use study is made. At any rate Federal irrigation will account for nearly three-fourths of the projected 6.8 million acre-foot growth after 1970. Accomplishment of this schedule depends upon a rate of development which has not been reached in years past, accounting for the shifting date for ultimate use. Under present guidelines of the WRC, federally sponsored irrigation development is difficult to justify.

46. "Ultimate" Depletions. A key conclusion formed by the Committee concerned minimum releases from the main stem system. Releases approximating 6,000 cfs from Gavins Point were found necessary to meet the Kansas City requirements, which also average 6,000 cfs, since downstream inflow during drouth periods scarcely offsets losses.

47. Once this lower bound had been set, maximum depletions compatible with it could be determined. During a repetition of the hydrologic cycle from 1898 to date, and based upon pre-development levels, the main stem reservoirs could support a year round release of 6,000 cfs throughout the most severe drought period, which extended from 1930 through 1941, and at the same time tolerate a depletion to natural flows of 16.3 million acre-feet per year. In years of better yield, higher releases would ensue. The value of 16.3 million acre-feet then becomes a limit to the extent of permissible depletion growth in light of present-day thinking as reflected by the Ad Hoc Committee on Water Marketing. By comparison, this is seen to be 3 million acre-feet more than the future depletion without industrial use as projected by Figure C-3.

48. But whether projected changes in consumption are accurate or wrong, whether the projected rate of change is too slow or too fast, so long as there exists a recognized need of 6,000 cfs to the lower basin, sustained upstream depletions cannot be greater than 16.3 million acre-feet a year unless further storage is developed.

POSSIBLE INDUSTRIAL DEPLETIONS

49. Projected depletions discussed in the last section include no amount attributed to industrial use. On a relative scale, normal industrial depletions are insignificant in comparison to agricultural use. Even a water-intensive industry such as sugar-beet processing which diverts about 3,000 acre-feet of water during a four-month season consumes only a small fraction of this amount. Noteworthy exceptions are today's large thermal-electric plants and the infant

technology of coal gasification.

50. Recent estimates of total consumptive use in a typical 1,000 megawatt coal-fired power plant range from 12,000 to 15,000 acre-feet per year for wet cooling, depending upon whether a wet SO_2 scrubber is required. [1/] Coal gasification to augment declining natural gas supplies also has the potential for appreciable consumptive use. Plans for earliest production rely on the Lurgi process, a less than ideal batch process. Continuous-stream technology is under development in Great Britain, but definitive information on water use is not yet available. One utility which has been planning for development of a 250,000,000 cubic foot per day Lurgi Plant in North Dakota has applied for a permit to divert 17,000 acre-feet of water per year from Garrison Reservoir. Such amount is regarded by authorities as more than adequate for a single plant of this size. Consumptive use of 10,000 acre-feet per year appears to be a reasonable upper limit.

51. **As perceived in the Northern Great Plains study already referred to, the rate at which western coal could be utilized in the year** 2000 would be limited by such constraints as transportation, capital, and skilled labor, to a maximum of about one billion tons a year. Of this, some 45% was projected for use in the basin and the rest attributed to export.

52. Added to these assumptions concerning development and the at-plant consumption of water, there is a requirement for water to encourage revegetation via supplemental irrigation. Finally, additional municipal needs would result from service to a growing population. The Great Plains study concluded that to support the maximum extraction rate of one billion tons of coal per year in 2000 would require a population increase of half a million people, who would consume 14,000 acre-feet annually.

1/ Effects of Coal Development in the Northern Great Plains April 1975

53. The total then for such a rate of extraction would be:

Coal conversion	618,000	acre-feet per year,
Municipal	14,000	
Revegetation	31,000	
Slurry pipeline	187,000	
Total	850,000	acre-feet per year

54. These values are based on the revegetation of acreage affected by extraction of one billion tons in a drought year, the processing of 450 million tons, and the export of 550 million tons, half of which would be transported by slurry pipeline.

THE STATE-REGIONAL FUTURE

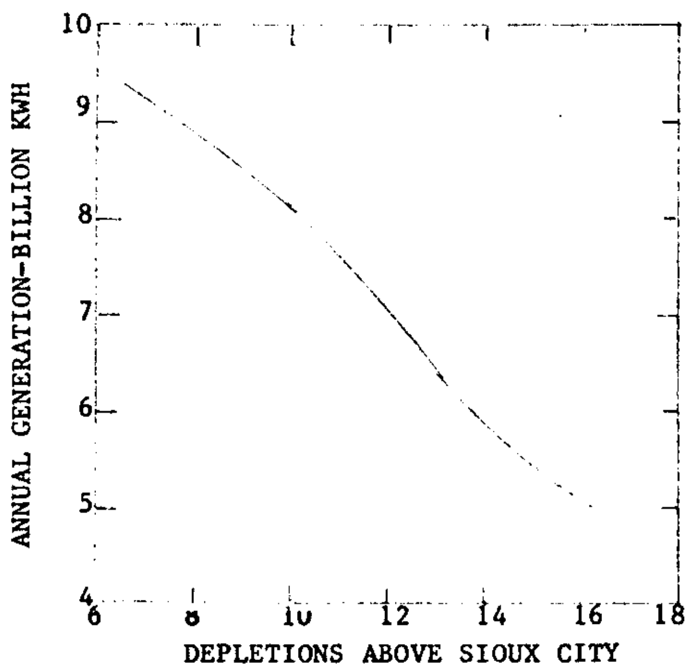
55. Responding in 1976 to the statutory requirement for update of the Missouri River Basin Comprehensive Framework Study/National Assessment, the Missouri River Basin Commission elicited data from the basin states on their estimates of present and projected future water use. Input came from the same State agencies which had served on the Framework Study Groups and the Ad Hoc Committee on Water Marketing, but future growth of depletions was projected only to the year 2000.

56. These projections are of interest in comparison to conclusions drawn by the Ad Hoc Committee regarding the near term availability of water for marketing to industry. Although the State Regional Future (SRF) quantified average annual depletions above Sioux City in 1975 approximately 40 percent above the Ad Hoc values and 30 percent above the Framework, this is only a part of the problem. As stated earlier, the Ad Hoc evaluation slowed the estimated rate of future growth so that full attainment of consumptive uses other than for energy would not occur until 2060, forty years later than the Framework estimate. SRF approaches this level for the year 2000. Such depletion growth would require marketing assumptions quite different from those upon which the MOU was predicated. (See P. C-103)

EFFECTS OF DEPLETIONS ON HYDRO-POWER GENERATION

57. The present hydro-power installations in the main stem dams are large enough to accommodate any discharge requirement short of sizeable flood release, with the exception of Gavins Point. Elsewhere in this report is an analysis of the desirability of additional units, which would still further reduce the necessity for "spills", i.e., discharges bypassing the turbines. This being true, every acre foot of water in additional depletions from the system will result in a reduction of kilowatt hours generated, thus leading to some observations that even at today's depletion level, there is no surplus water in the system. The extent by which generation drops as depletions grow has been established through many studies by the Corps of Engineers and is shown on Figure C-4.

FIGURE C-4 REDUCTION IN MAIN STEM GENERATION



58. Operation of the main stem reservoirs is geared to providing releases commensurate with the depletion level throughout the drought of record; in other words, the less water flowing in, the less flowing out. Consequently, reservoir levels — and hence, capability — for a given water year would be essentially the same over a wide range of depletions. Put another way, peaking capability is highly insensitive to the growth of depletions. Since the capability of the system (in kilowatts) remains quite stable, the economic cost of the lost generation shown in Figure C-5 may be expressed as the cost of generating the lost kilowatt hours by alternative sources. These values have been computed on the basis of prices furnished by the Federal Power Commission and are shown in Figure C-5.

59. Another method of looking at the usefulness of hydro-power production is to determine the plant factor. This is defined as the ratio of the average generation to nameplate generation. Expressed as a percentage, it reflects the extent to which the plant's potential output is being used. The plant factor of a generator may vary widely depending upon its power source and the role assigned to it in the system. Base loaded nuclear or fossil fueled thermal plants will operate at high annual load factors - perhaps 60%. Daily and even monthly load factors can approach 100%. Combustion turbines and hydro-plants are suitable for so-called "peaking" operations, generating for only a few hours a day during periods of maximum demand. They may operate at plant factors of ten percent or less. The changing plant factors of the main stem hydro-projects from the 1970 to the ultimate depletion level are shown in Figure C-6.

60. The effect of future depletions on main stem hydro-power generation may be summarized as follows: peaking capability in kilowatts will be reduced by less than ten percent; energy generation will decline about 500 kwh for every acre foot withdrawn. Based on 1976 costs of generation, this energy could be replaced for one to three dollars an acre foot, depending on the fuel used.

FIGURE C-5 COST OF ALTERNATIVE ENERGY

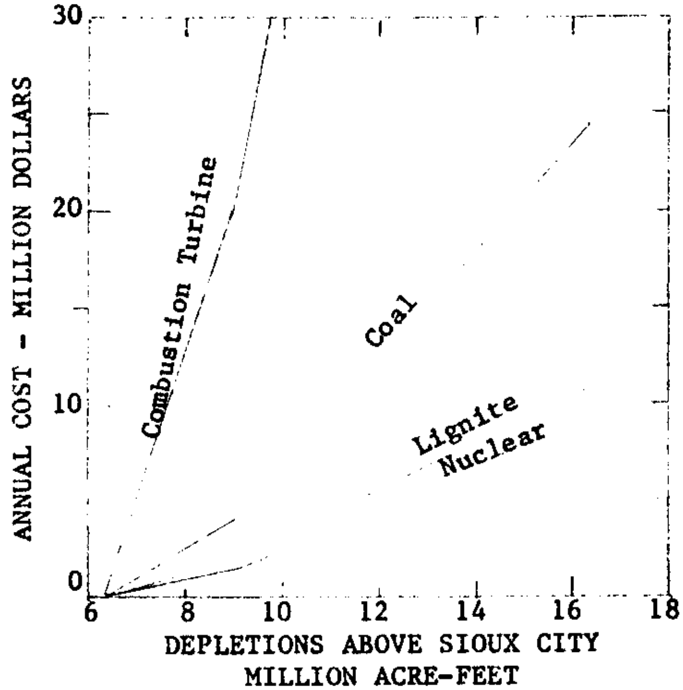
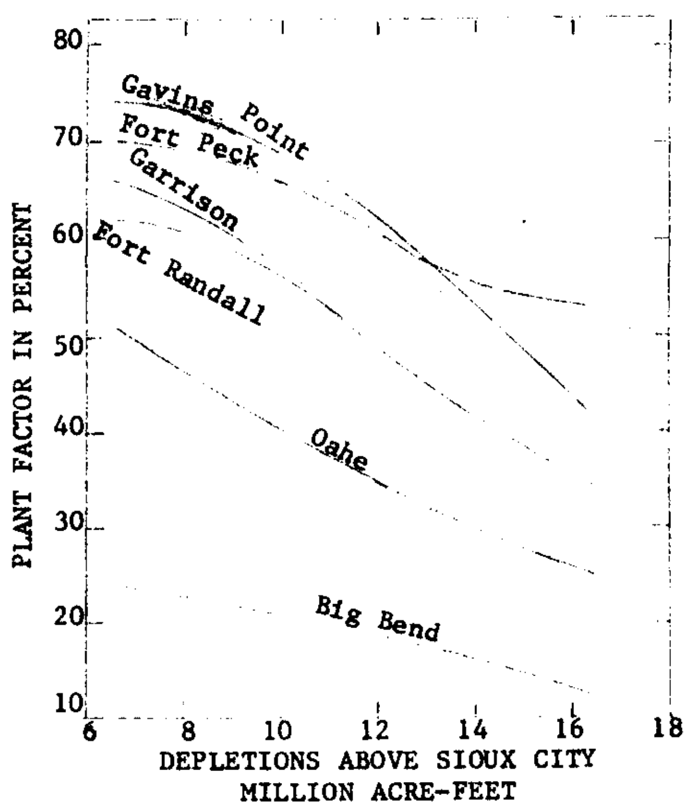


FIGURE C-6 REDUCTION IN PLANT FACTOR



EFFECTS OF DEPLETIONS ON WATER QUALITY

61. During periods when inflow to the main stem reservoirs is average or better, increased consumptive use will not seriously affect water quality. It is the protracted drouth periods which impose the greatest stress not only above Sioux City but in the lower river as well. Such drouths adversely affect reservoir water quality in two principal ways: first, by lowering the ratio of flood inflow to total flow, and second, by lowering reservoir releases and increasing retention time in the reservoir. The first factor is independent of depletion levels; flood flows, with their relatively low concentrations of dissolved solids, tend to improve water quality; their absence is felt at all depletion levels.

62. The second factor, increased retention time is affected both by drouth and by depletion level, since both work to reduce the amount of water available for release from storage. Longer retention times will have significant effects primarily at the three smaller reservoirs, Big Bend, Fort Randall and Gavins Point. Using Fort Randall as an illustration, the time required to discharge a volume of water equal to the reservoir storage is:

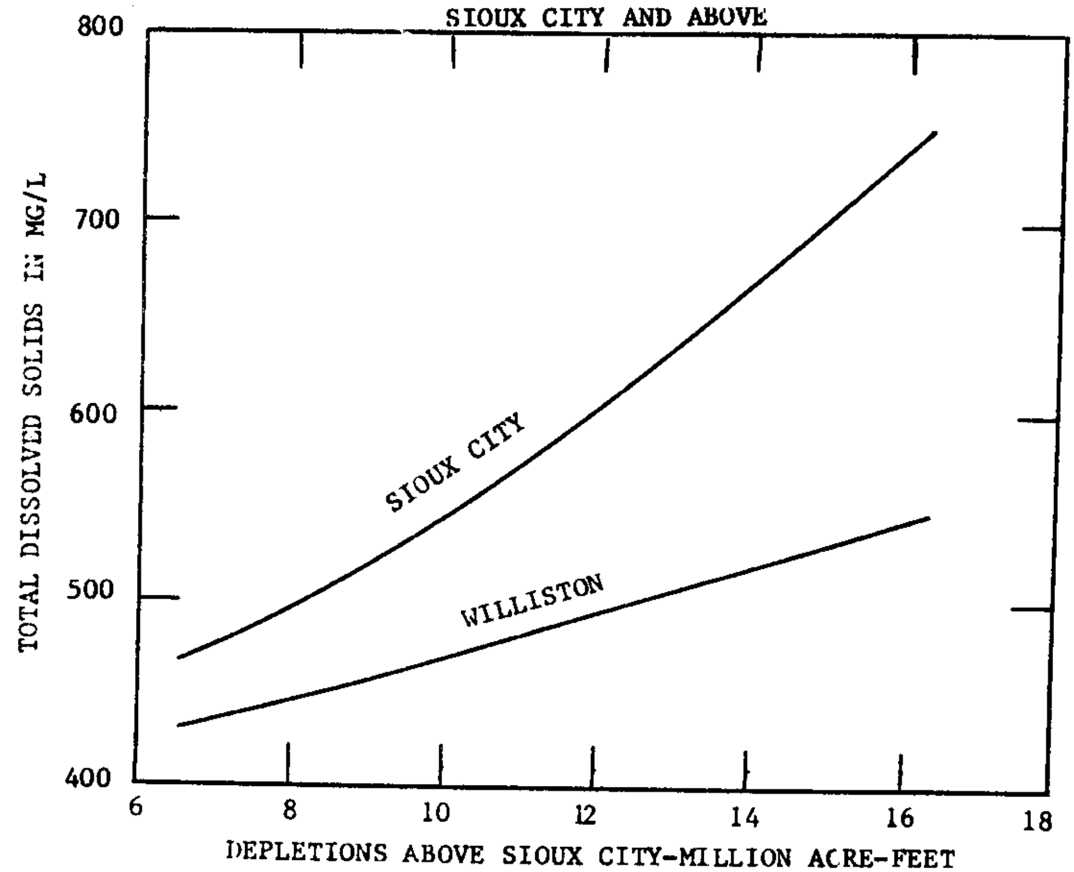
	Retention Time In Months	
	with 1970 Depletions	with Ultimate Depletions
Normal Inflow	2	3-1/2
Drouth Inflow	3	9

63. One consequence of longer retention time is an increase in the productivity of the epilimnion -- greater density of primary biota with the possibility of taste and odor problems. Another is an increase in reservoir stratification -- more frequent and long lasting thermoclines. This can result in discharges with very low amounts of dissolved oxygen, since the power intakes at all three projects are located near the bottom of the lake.

64. Total dissolved solids (TDS) are an important index of water

quality. Although drinking water standards commonly set 500 mg/l as the desirable upper limit, many basin water supplies exceed that limit by several fold. Average values in the Missouri, however, have ranged from below to only slightly above this criterion. With the growth of streamflow diversions and the corresponding increase in return flows carrying high levels of TDS, this condition may be expected to change. The Missouri River Basin Comprehensive Framework Study projected conditions for two points within the study area, Williston, North Dakota and Sioux City, Iowa. These data have been confirmed by EPA as being the best projections available today; they are presented in graphical form in Figure C-7. It should be noted that these are average values; during drouth periods, higher concentrations will occur due to the absence of flood flows.

Figure C-7
CHANGE IN TDS WITH DEPLETION GROWTH
SIOUX CITY AND ABOVE



EFFECTS OF DEPLETIONS ON THE ENVIRONMENT

65. Clearly the future of the Missouri River is one of declining streamflow, with some uncertainty about the exact rate of decline but with an "ultimate" possibility of reducing today's average annual flow at Sioux City by more than 40 percent -- to 12 million acre-feet per year. Projections of the geographic distribution of these added depletions indicate that flows at Fort Peck and upstream will be reduced only to a minor extent -- perhaps 15 to 20 percent. Downstream of the Yellowstone, however, the impact will be very similar to that experienced at Sioux City, with reductions in flow ranging from 35 to 45 percent.

66. Reduced inflow will be reflected in lower average lake levels. Criteria governing operation of the three largest lakes place some priority on holding stored water upstream; this is reflected in the amount of lake lowering at Fort Peck, Garrison and Oahe projected to average 10, 16 and 30 feet, respectively. Lake Francis Case elevations are expected to range from three to six feet lower than at present as a result of a different operating requirement. Early winter reductions in lake level as system releases decrease are scheduled to improve power generation. Lake Sharpe and Lewis and Clark Lake levels are expected to be unaffected by changes in water supply.

67. The biological consequences of these depletions have not been studied in detail; therefore, only a generalized evaluation can be presented here.

68. The range of reductions in volume at Fort Peck Lake, Lake Sakakawea and Lake Francis Case attributable to future depletions described above should have little change in the lakes' biocoenosis. A recognized major limitation to a more diverse and stable aquatic community in these three lakes is the almost total lack of a vegetated, stable littoral habitat. This condition is expected to persist into

the future. Lake Oahe has a similar limiting habitat condition that will remain unchanged by future depletions of the lake volume. However, Oahe lake waters interface with numerous areas of sand and gravel deposits which function as walleye (and to a much lesser extent, sauger) spawning grounds. A 30-foot reduction in the lake level will expose many of these deposits causing a significant reduction in walleye spawning sites. Although a reduction in volume is not expected to occur at Lake Sharpe or Lewis and Clark Lake, reduced inflows to both lakes will significantly increase the flow-through time (greater retention time of the lake water). This will permit a longer time for the extraction of nutrients by producer organisms and a longer time for this foodstuff to be available to the fish. In addition, fish hatched in the upper reaches of the lakes or in the river above the lakes will have a longer time in which to achieve sustained, directed mobility and, thus, keep their larval forms from being carried through the lakes to the river below.

69. Reduced average annual flow in the open river reaches between Garrison Dam and Lake Oahe and Fort Randall Dam and Lewis and Clark Lake can be expected to have its greatest effect on restricting fish spawning migration from the primary river channel up tributary streams because of insufficient water depths at the tributary mouth. The frequency and amplitude of river stage fluctuations will not change appreciably from fluctuations caused by peak power generation under non-depletion water conditions; the time period of zero or near zero releases, however, will be extended. This will permit greater opportunity for fish to become stranded in small pools or pockets of water thus making the fish more vulnerable to desiccation, and to avian (bald eagle primarily in winter) and mammalian predation. Reduced average annual flows will cause the adjoining land water table to lower. The effect anticipated is a change in the native vegetation community which will favor the more xeric plants. This changed condition can be expected to lead in a number of areas to conversion from native, miscellaneous plant communities

to terrestrial crop production.

70. The biological effects of reduced average annual flow generalized above will also apply to the river reach between Gavins Point Dam and Sioux City, Iowa, except that the effects associated with zero and near zero flow in the upper open river reaches would not occur. In addition, there should be opportunity for production of organic matter in the space between the low, non-navigation flow channel and the shoreline of the navigation flow channel during the fall and spring of each year. The produced organic matter, at least a great portion of it, would be incorporated into the aquatic ecosystem by the navigation flow and become drift material. This potential foodstuff (drift) would be available in this reach of the river, and contribute to the allochthonous material in the river downstream of Sioux City, Iowa.

EFFECTS OF DEPLETIONS ON RECREATION

71. Reduction in lake surface elevation at Fort Peck, Lake Sakakawea, Lake Oahe and Lake Francis Case should have little overall effect on public recreation opportunities. Associated with the lowering of the pools is the migration of the lakes' upper reaches downstream; this situation will be most pronounced at Lake Oahe. There, the upper end of the lake would move to approximately fifty miles below Bismarck, North Dakota, placing Beaver Creek public use area at the lake's extreme upper end. General Sibley Park, Hazelton public use area, and Fort Rice public use area would no longer be lake oriented. Although recreation activities at these areas would be altered, there should be little overall loss of public use. Some boat ramps and swimming beaches might require extensions riverward to continue their usability.

72. Continuation of the Missouri River navigation project would probably become infeasible when average flow past Sioux City fell to the range of 14 to 15 million acre-feet per year, but today's pattern of releases from Gavins Point of 25,000 cfs or more for at least some

part of the ice free season (most probably in early summer) would occur in about one year out of two. In other years, differences between summer and winter flows, as well as their absolute magnitude, would be markedly smaller than they are today. During protracted drouth periods, both summer and winter discharges from Gavins Point can be expected to average close to 6,000 cfs under ultimate depletion levels. These effects will be observable at Sioux City and well downstream.

73. Recreation opportunities in the Gavins Point-Sioux City reach would be little affected when Gavins Point releases approximated 25,000 cfs during the summer months. However, during the years when summer releases were significantly lower (down to a floor of 6,000 cfs) a material reduction in public use could be expected. The recreational activities associated with areas of sand bar and shallow water during the 25,000 cfs flow condition could not be accommodated in the 6,000 cfs, low flow channel. Swimming, sunbathing and fishing are the dominant uses that would be affected by a reduction approaching 50 percent during the lowest flow year. Therefore, an estimated 25 percent loss of public use could be attributed to the reduced average annual flow of the Missouri River in the reach between Yankton and Ponca State Park.

Consumptive Use Alternatives

74. The instream functions discussed above are insensitive to the mix of consumptive uses which result in depleted streamflow. The magnitude of that depletion and the locale of its diversion fix the extent of its impact on the stream. However, if more water is withdrawn than is consumed, return flows can have an effect on water quality. Subject to these qualifications, the interaction of consumptive uses and the evaluation of various mixes of - to be specific - irrigation and industrial consumption, are confined to their effect upon one another; it does not matter to power generation or recreation or navigation whether total depletions result from three million

acre-feet of industrial use and seven million acre-feet of irrigation or alternatively from one million and nine million acre-feet.

75. There does, of course, exist the possibility that some instream use will attain such a high public priority as to limit the sum total of consumptive uses. Instream flow minima to maintain fish population might decree a revision of the example just cited; instead of industry and irrigation competing for shares of ten million acre-feet in depletions, society could opt for only five million to be available, with the rest reserved to flow down the river. Admittedly this does not reflect the past trend in water resource development; the concept is, however, receiving increasing support today. Nonetheless, formidable obstacles stand in the way of early implementation of any extensive program to preserve instream flows. Most western law expresses an opposite emphasis - that of encouraging and codifying the rights to beneficial consumptive use. The O'Mahoney-Millikin Amendment mentioned earlier is an example of legislative preference for consumptive, rather than instream, water use.

76. Aside from the possibility that changing values could affect their combined scope, irrigation and industrial use can interact in one of two ways:

- There may be enough water to fill the foreseeable requirements of both functions. This will be recalled as the condition developed in the Framework Study and updated by the Ad Hoc Committee on Water Marketing.
- There may be less than enough water to meet the full demands of both functions. This is the future to be deduced from the State-Regional projections, which predict 14.7 million acre-feet of depletions by the year 2000, of which less than 500,000 acre-feet are attributed to manufacturing, mining, and steam-electric plant use combined.

77. If there is less than enough water to go around, the extreme possibilities are, on the one hand, that irrigation be allowed to

use all it possibly can, with industry getting the residue; on the other, industry could be fully supplied, with irrigation taking what is left. Between these two limits, of course, lies a wide range of possibilities for joint sharing in the water supply and in the shortage.

78. Many of the factors influencing local preference as to the industrial-agricultural mix have little to do with national or regional economics. They range from opposition to social upheaval as shanty towns bloom around a mining or construction area, to possible loss of the agricultural base if stripped lands are not adequately reclaimed, to the threat of environmental degradation of land, air and water. In point of fact, some of these impacts are materializing without the commitment of water resources, through export of strip-mined coal by unit train.

79. To the extent that economics play a decisive role in allocating a limited water supply between industry and agriculture, industry clearly comes out the winner. Table C-1 compares effects of three coal-using industries and the strip mines themselves with the alternative of agricultural use. Another basis for comparison is the value of the coal or crops produced by committing the same water resource, 1,000 acre-feet per year.

80. The Framework Study found that irrigation would increase the yield of corn equivalents [1/] by 53 bushels per acre. Using current normalized commodity prices published by the Water Resources Council, these equivalents may be converted to gross annual cash value of \$2.42/bu x 53 bu/acre x 526 acres = \$6,750 per 1,000 acre-feet of water per year.

1/ Corn equivalents are determined by multiplying each crop by its current normal price and then dividing by the current normal price of corn.

Table C-1 - ECONOMIC AND SOCIAL EFFECTS OF WATER USE FOR INDUSTRY AND FOR AGRICULTURE PER 1,000 ACRE-FEET OF WATER PER YEAR 1/

	Permanent Employees	Direct and Indirect Population	Assessed 3/ Valuation Millions of Dollars	Coal Millions of Tons
Thermal Electric 2/ Generation 1,000 MW	6.2 To 25.7	39 To 160.7	3.45 To 14.29	0.15 To 0.64
Gasification (Lurgi) 2/ 250 million cu. ft./day	61.2 To 178.9	382 To 1118	9.89 To 28.95	0.68 To 2.00
Liquefaction (Solvent Refined Coal) 100,000 bbls/day	136.4	854	22.73	3.2
Slurry Pipeline 25 million tons/year	4	25	2.03	1.33
Strip Mines 10 million tons/year	130	812.5	15.61	4.36
Irrigation 4/	5	31	0.13	N.A.

1/ Source (except irrigation); COAL DEVELOPMENT ALTERNATIVES . . ., D. D. Freudenthal, P. Ricciadelli, and M. N. York, Wyoming Department of Economic Planning and Development, December 1974.
2/ Estimated water use per plant ranges from 7,000 to 29,000 acre-feet for thermal generation; 4,750 to 13,900 acre-feet for gasification; 11,000 acre-feet (dry cooling only) for liquefaction. Ranges vary with cooling process: once through, cooling ponds, dry cooling, or wet cooling towers. Ranges in the table reflect these ranges in water use and associated plant.
3/ Assessed valuation based on 25 percent of total expenditures for thermal generation, and liquefaction facilities; 25 percent of market value of irrigation land.
4/ Irrigation: 1,000 acre-feet of water for 526 acres @ 1.9 acre-feet/acre; 160 irrigated acres per farm; 1.5 employed per farm; irrigated acre market value @ $1,000/acre.

81. The Northern Great Plains study reported a mine-mouth cost of $2.70 a ton for coal. The yield of 1,000 acre-feet used for thermal electric generation at the poorest water effective rate in Table C-1 is 150,000 tons of coal or $400,000. The value of the energy generated would be many times that amount but so, of course, would the necessary capital investment.

82. Some comments have also been made to the effect that diversion of water from the main stem system to use in the production of thermal energy is unwise since it results in a reduction of hydro-power generation. The ratio, however, of thermal kilowatt hours gained to hydro-power kilowatt hours lost exceeds 6,000 to 1. Evidently, the national energy budget is best served by making water available to serve the needs of thermal power generation.

Effects Outside Study Area

83. Although the southerly limit of the study area is Sioux City,

Iowa, the effects of upstream withdrawal extend far below that point and their impact must be evaluated. The following sections discuss the effects of growing depletions, up to the "ultimate" of 16.3 million acre-feet, as they will affect navigation, water quality, water supply, recreation and the environment.

NAVIGATION

84. Under present operating criteria, average Sioux City flows as regulated to serve navigation have a maximum target of 31,000 cfs; any flow in excess of that is either to make up for deficient lower-basin inflow or to evacuate flood storage. The minimum flow is 25,000 cfs; when main stem storage drops too low, water is conserved by shortening the season length rather than by cutting streamflow below 25,000 cfs. Similarly, there are no plans to support a navigation season of less than four months. Commercial navigation was not in being during the drouth of the 1930s and, consequently, no hard evidence exists as to how long the industry would endure a succession of curtailed seasons. The assumption has been made, however, that barge operators could not afford to mobilize for a season shorter than four months. The effect upon navigation of growing main stem depletions thus is felt first as a reduction in rate of flow; after the flow bottoms out the next effect is a shortening of season, and finally, navigation releases are eliminated entirely.

85. One way of quantifying this effect is to define reduction in service to navigation as being identical to reduction in average annual flow. On this basis, if service to navigation under 1970 conditions is taken to be 100 percent, each new depletion of 1,000,000 acre-feet will reduce navigation service by eight percent. With ultimate depletions, then, service to navigation would be 20 percent of the 1970 level.

86. While curtailment of flow can increase operational problems

such as dredging cost and time lost in grounding; it is not in itself an obvious indicator of the increasing number of shortened seasons. During these shortened seasons, barge operators cannot keep their equipment on the river no matter how great their willingness to endure operational problems. Figure C-8 shows how the percentage of full and near-full length seasons declines as depletions increase. It is apparent from these curves that dependability of the barge transportation system deteriorates rapidly once depletions exceed 13 million acre-feet. In about one year out of five, it is evident that system inflows are sufficient to provide a full season even with ultimate levels of depletion. It is equally evident that in more than half the years this level will not provide enough water for any navigation service at all.

WATER QUALITY

87. Future quality of water in the Missouri River downstream of the study area will be affected not only by the upstream depletions which have been discussed at some length, but also by depletions from the tributaries below Sioux City. While growing depletions are cutting back the average annual flow of the Missouri River at Sioux City from the 1970 level of 22 million acre-feet per year to an ultimate level of 12 million, the flow at Hermann - lowermost gaging station on the river - is projected to decline by some 15 million acre-feet, half again the size of Sioux City's reduction in flow.

88. The impact of these reduced flows in the lower river on total dissolved solids will be less critical than might first appear, according to projections from the Framework Study. Figure C-9 repeats Figure C-7 data on Sioux City data as a base and also shows three downstream stations which indicate modest reductions in TDS downstream of Omaha. Attainment of these reductions at Kansas City is rendered somewhat problematical, should recent projections for heavy irrigation use of the Platte and Kansas Rivers materialize.

FIGURE C-8 NAVIGATION SEASON CURTAILMENT
CAUSED BY STREAM DEPLETION

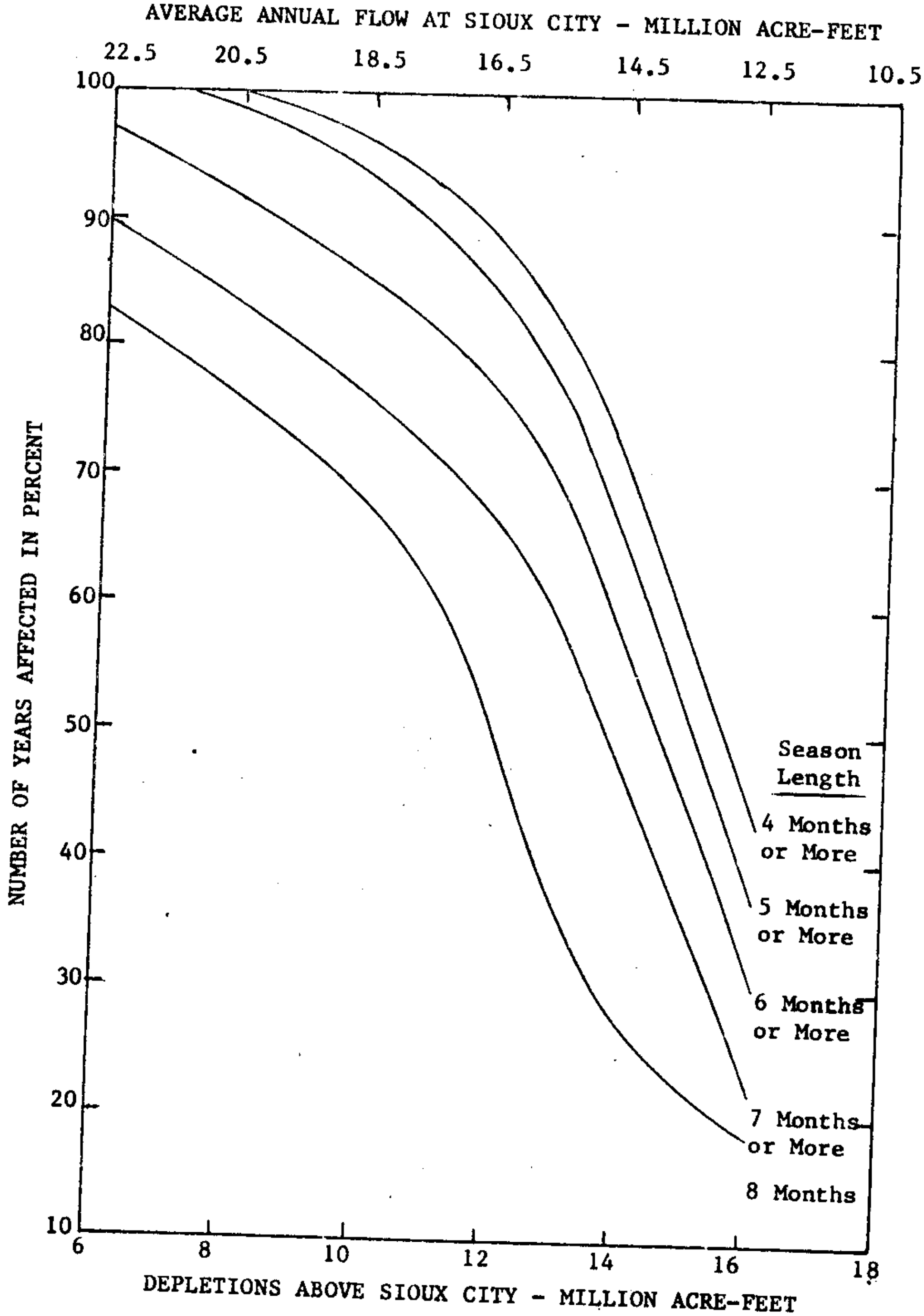
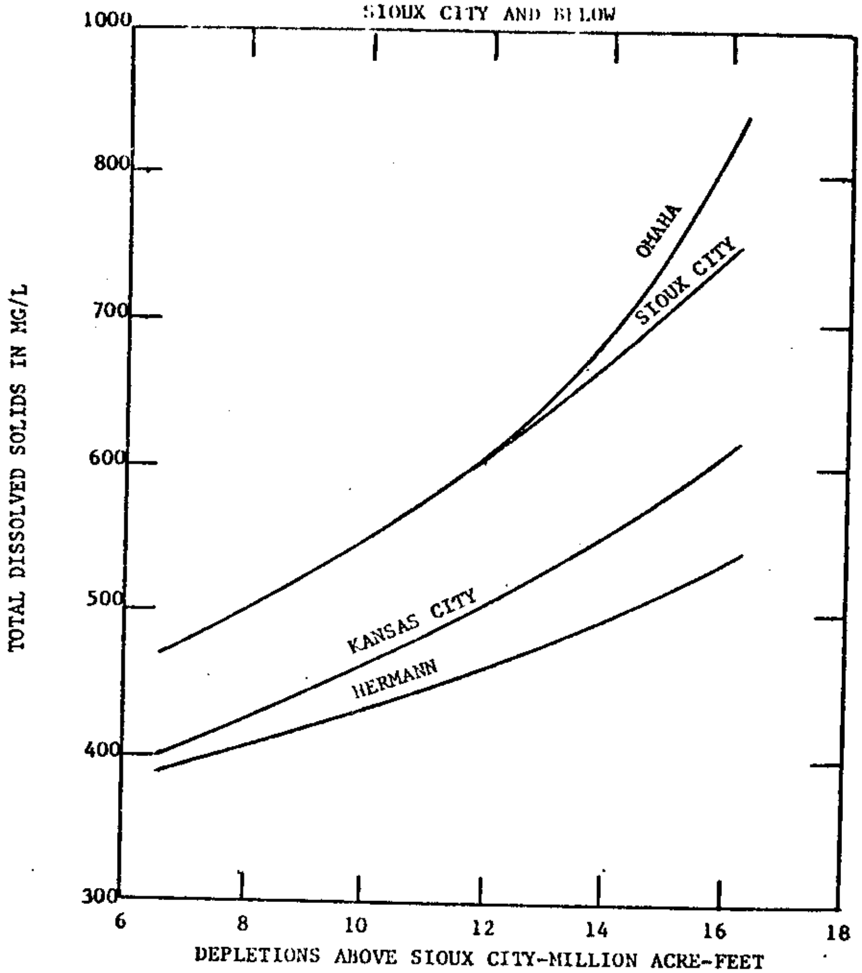


Figure C-9
CHANGE IN TDS WITH DEPLETION GROWTH
SIOUX CITY AND BELOW



89. Other principal water quality parameters show an opposite geographic trend, with quality declining in a downstream direction. Major sources of pollution historically have been sewage effluent and urban and agricultural runoff. The chief violation has been that of coliform level, with isolated instances of inadequate dissolved oxygen also recorded. The latter have been identified from observation of resultant fish kills and typically have been caused by a "slug" or concentrated point discharge of contaminants high in BOD.

90. Whether water quality in the lower river remains tolerable in

future years obviously depends much more on the development of treatment facilities than it does on the growth in depletions. Increases in population and in industry without corresponding improvements in treatment can severely depress dissolved oxygen levels downstream from Omaha even at today's flow levels. If, however, present levels of point source loadings can be brought closer to the "zero-discharge" goal, future depletions will result in conditions no worse than those observed today.

ENVIRONMENTAL EFFECTS

91. Future depletions will have two effects of environmental concern: lowered water levels and the associated threat to water quality.

- Projected water levels will significantly reduce or eliminate the few remaining backwater areas downstream from Sioux City. These areas normally exhibit high primary productivity compared to the main channel of the river and are the chief locale for fish spawning, benthos production, and overwintering for reptiles and amphibians.

- Lowered water levels will create difficulty for fish attempting to reach spawning areas in tributaries, particularly the shallower tributaries. This, in conjunction with the partial dewatering of the tributaries will make spawning difficult resulting in decreased fish populations.

- Furbearers such as muskrat and beaver will show population declines due to habitat loss associated with the drying up of the backwater areas. However, the encroachment of flood plain vegetation into these areas may offset part of the loss and increase the habitat value for other mammals.

- Even assuming that additional treatment facilities keep pace with additional effluent loadings, the chance for "upsets" or accidental pollutant slugs is always present. Lesser flows mean lesser dilutive capacity; resultant increases in oxygen demand will persist longer in space and time. As a result, it is reasonable to expect somewhat more frequent and severe fish kills.

- Although TDS values below Omaha are projected to exceed drinking water standards by only a modest amount on the average, during drouth years substantially higher values may be expected. This can affect fish populations due to increased osmotic pressure particularly at the egg and larval stage. Changes of this type are generally tolerated by species such as the carp and bullhead while such as walleye and sauger exhibit considerably less tolerance. Detailed knowledge of species response to many dissolved solids is unknown; thus, quantative impacts remain to be evaluated.

RECREATION

92. From Ponca, Nebraska, to its mouth the banks of the Missouri River have been stabilized and from Sioux City downstream the river has been channelized for navigation. Reductions in streamflow along these reaches would lower river stages but would not alter the surface area of the river to any significant degree. River recreation today is made up primarily of bank fishing, pleasure boating and associated shore-based activities such as picnicking and camping. These activities center around the numerous private and public river access points. None of the major recreation activities would be eliminated by reduced annual flow; nor is it anticipated that any of the river access areas would be put out of commission. Probably, some boat docks and boat ramps would require extension or relocation to accommodate the lower stages.

Activities Prerequisite to Allocation of Water

93. Preceding paragraphs have discussed the past and present water supply, bracketing assumptions regarding the rate of future depletions, the ultimate limit to which these future depletions could be allowed to grow, the effect such depletions would have within and beyond the study area, and the competing jurisdictions which aspire to regulate Missouri River uses. Additionally, it has been explained why this study contains no attempt to establish an optimal allocation of water

use or of regulatory responsibility. This section will summarize the steps which must be taken when the time of hard decision making can no longer be put off.

DETERMINING PRIORITIES OF USE

94. Use of Missouri River water in future years may follow some comprehensive plan aimed toward accomplishment of predetermined objectives, or like Topsy and past administration of water rights, it may just grow. The doctrine of first-in-time is first-in-right prevails in all four of the States in the study area. Although a broad system of social preference may be superimposed on this doctrine of prior appropriation - use of water for domestic purposes ranking first, for example - it has only academic interest so long as there is enough water to accommodate all would-be users. Since enough water from the main stem reservoir appears probable at least for several decades, the only test which applicants for a water right would then have to meet would be that of beneficial use. This procedure also common to the four States, has at least one merit: it is straight-forward and timely, allowing quite expeditious approval or denial of proposals for water use.

95. The alternative of a comprehensive plan requires agreement on the individual priorities to be given to a broad spectrum of uses. Federal, State, and local agencies and private entities must interact to resolve such considerations as these:

- Is encouragement to industry desired?
- Is large-scale mineral development desired?
- Do social considerations make reservation of water for irrigation "better" than industrial development, regardless of the relative dollar benefits?
- Is it time to preserve benefits associated with instream uses such as recreation and fish and wildlife by putting limits on consumptive use, again regardless of relative dollar benefits?
- Where are the specific points of balance between industry

and irrigation, between instream and consumptive uses?

96. These difficult political questions are still far from resolved. Much deliberation in Congress, State legislatures and courts must ensue before a comprehensive set of priorities is adopted to regulate future water use. Particularly important and particularly troublesome will be incorporation of the flexibility to assign new priorities and shift old ones in response to the advent of new needs for water. Until these steps are accomplished, the obvious disadvantage to the comprehensive approach is inaction and delay in the development of water resources.

ESTABLISHING MARKETING POLICIES

97. Present arrangements for marketing industrial water from the main stem reservoirs are temporary. The Memorandum of Understanding between the Secretaries of Interior and Army, which spelled out interim procedures, expires 1 May 1977. It has been challenged by State interests as failing to develop authority for Federal sale of water and failing to reflect State views on designation of marketing agencies. In addition to these two issues, still other questions arise concerning appropriate charges to be made:

- Should the price of irrigation water and water sold to industry be the same, except for Federal irrigation projects' statutory utilization of interest-free money?
- Is it realistic to reallocate costs of a 30 to 40 year old system to establish the price of water by conventional separable cost analyses?
- Is it reasonable to sell storage space rather than water in a system of six tandem reservoirs with more than 50,000,000 acre-feet of multi-purpose storage?
- Should some fraction of the alternative cost less benefits foregone serve as the basis for pricing, even though this might result in differing charges to users from the same reservoir?

98. It is apparent that both in the area of priorities and social preference and in the area of marketing policy, conflicts of interest exist which are beyond the ability of a single agency to resolve. If this report succeeds in focusing attention on the need for such resolution and on the steps along the way toward meeting that need, it will have accomplished about all it can.

Status of Existing Plans and Improvements

99. In addition to the main stem reservoir system which has already been described, there are in being other improvements or plans affecting water resource development in the study area. They need identification to the extent that they might affect the formulation process in this report. Several are plans or commitments which the Corps itself is pursuing under authorities other than this study; the remainder will be itemized as activities of other agencies.

Corps of Engineers Activities

100. Under Section 32 of the Streambank Erosion Control and Demonstration Act of 1974 two of four specified demonstration areas in the United States are located on the Missouri River, in the reach between Fort Randall Dam and Sioux City, and in the reach below Garrison Dam. The intent of this program is to develop a demonstration of structural means for controlling bank erosion with a view toward identifying the most cost effective techniques. Nine specific sites, which are responsive to the intent of the Act, have been selected -- three each in Nebraska, South Dakota, and North Dakota. Construction is scheduled for completion during FY 1978.

101. Since they first filled sufficiently to utilize their flood control storage zones (in 1965 and 1968, respectively,) Garrison and Oahe reservoirs have been the subject of complaints by landowners adjacent to project boundaries. In a number of instances, surveying errors during establishment of the original boundaries have indeed resulted in impoundment of flood waters on private property. An additional problem became apparent when the basin's largest runoff volume of record occurred in 1975. Moderately high inflow to Oahe coincided with an unusually high Oahe pool level. The result was lowland flooding and swamping which affected about 3,000 acres of private land between the project boundary and the old highway bridge at Bismarck. Ongoing studies aimed at remedying these deficiencies are being conducted under existing project authorities.

102. Compensation under the Fish and Wildlife Coordination Act of 1958 for losses occasioned by the construction and operation of the Missouri River main stem reservoirs is limited to Oahe and Big Bend by the effective date of the law. Mitigation actions to be implemented for the North Dakota portion of Oahe have been authorized and are presented in Senate Document No. 91-23, **but no land acquisition has been accomplished because the Governor of North Dakota and the Congressional delegation have withdrawn support. The Corps of** Engineers is processing (1976) a report recommending certain mitigative actions for the South Dakota portion of Oahe and Big Bend.

103. On 24 February 1975 the Secretaries of Interior and Army entered into a Memorandum of Understanding pertaining to the six Missouri River main stem reservoirs. Its stated purpose was "to expedite the use of water for energy development . . .;" its term was set at two years. During that time:

The Secretary of Interior was to determine the amounts of water presently excess to future irrigation needs.

- The Secretary of Army was to determine how much of this excess could be made available to industry.

● The Secretary of Interior was designated as having lead agency responsibility in contracting for the marketing of such water and for complying with the National Environmental Policy Act.

Activities of Other Agencies

104. A 1974 study by the Bureau of Outdoor Recreation addressed the potential of the Lewis and Clark Trail, which stretches from St. Louis to the mouth of the Columbia River and follows the Missouri River across the entire area of this study, for classification under the National Trails System Act (Public Law 90-543). It was concluded that a National Historic Trail classification should be added to the provisions of the Act, and that the Lewis and Clark Trail should be included in that category. Management would be by the agency most closely associated with a given portion of the trail. No legislation has yet been introduced.

105. The Charles M. Russell National Wildlife Range and the UL Bend National Wildlife Refuge are managed by the U. S. Fish and Wildlife Service. Both areas are located in northeastern Montana, adjacent to Fort Peck Lake. The purpose of the wildlife refuge is to provide nesting, resting, and feeding habitat for ducks, geese, swans, and other migratory birds. The game range emphasizes management of resident wildlife species, as well as migratory waterfowl. Wilderness proposals for the refuge and game range are presently before Congress. At the Charles M. Russell Wildlife Range the proposal covers 15 areas totaling 161,000 acres - about 15 percent of the total range. Congress has called for a mineral survey of the range to be conducted by the U. S. Geological Survey before action is taken on the bill. The UL Bend wilderness proposal comprises about 21,000 acres - about half the refuge. It has not been acted upon by Congress.

106. A 1975 study by the Bureau of Outdoor Recreation examined the Missouri River from Fort Benton, Montana, to Ryan Island for inclusion

in the National Wild and Scenic Rivers System. The segment from Fort Benton 149 miles downstream to Robinson Bridge, known as the Missouri Breaks, has been so designated by PL 94-486. The Bureau of Land Management will be the principal managing agency.

107. During 1975, the U. S. Fish and Wildlife Service completed more than a decade of study of fish population dynamics at the four lower-most reservoirs. Documentation of these studies will be completed by 1977. Investigations and research are now shifting from South Dakota to North Dakota and Montana. F&WS's work in Fort Peck Lake and Lake Sakakawea is related to energy development in these two states. Limnological and fish reproduction studies will be done in those portions of the lakes most directly affected by mineral resource development. State agencies have also conducted extensive studies at the lakes.

108. A 1968 study by the Bureau of Outdoor Recreation recommended establishment of a National Recreation Area consisting of the lower five main stem lake projects. The Corps of Engineers was recommended as the managing agency. Bills to establish the NRA were introduced in the 90th and 91st Congress (1968 and 1969), but were not brought out of Committee. A similar proposal was brought before the Missouri River Basin Commission in 1974, with the thought that indorsement might stimulate favorable reception by Congress. Again, however, no action was taken.

109. The Lake Audubon National Wildlife Refuge is located on a subimpoundment of Lake Sakakawea. The entire lake was originally permitted to the U. S. Fish and Wildlife Service for management; the northern half was subsequently licensed to the State for management. The refuge is managed primarily for migratory birds, though enough deer and antelope are produced to allow limited big game hunting.

110. The Little Missouri National Grasslands, Custer National Forest, abut a portion of the Lake Sakakawea Project in North Dakota.

This is the McKenzie Ranger District, 503,047 acres in size.

111. Land acquisition is underway at the Knife River Indian Villages National Historic Site located at the confluence of the Knife and Missouri Rivers about 14 miles downstream from Garrison Dam. The National Park Service has acquired 135 acres in fee and final acquisition will total approximately 1,300 acres in fee and easement.

112. The Garrison Dam National Fish Hatchery is located below the dam near Riverdale, North Dakota. The hatchery produces northern pike, walleye, smallmouth bass, rainbow trout, coho salmon, and Lake trout for distribution in western North Dakota and northwest South Dakota.

113. The Garrison Diversion Unit, North Dakota-South Dakota, an element of Pick-Sloan Missouri Basin Program, is located in central and eastern North Dakota and northeastern South Dakota. The initial stage will provide a full water supply for the irrigation of 250,000 acres, presently dry farmed, with ultimate development potential of about one million acres. Water for irrigation and the various other purposes will be diverted from Garrison Reservoir into a regulating reservoir on a drainage divide between the Souris, James and Sheyenne rivers. From there, water will be distributed by canals and laterals as needed. The plan provides for restoration of Devils and Stump Lakes for pollution abatement, municipal and industrial water, recreation, conservation and enhancement of fish and wildlife, and flood control. Estimated completion dates for initial water use are the early 1980's; right-of-way acquisition and relocations are about 20 percent complete. Initial diversion from Garrison Reservoir is expected to average 871,000 acre-feet per year, most of which would leave the Missouri Basin. Ultimate annual diversion may run 2.600,000 acre-feet. At this writing the project has been subject to administrative and legislative review for continued funding.

114. Lake Pocasse National Wildlife Refuge, located on Lake Oahe

near Pollock, SD, consists of 2,540 acres of land and water, and is managed for migratory waterfowl. The southwest portion of the lake has been developed for recreational activities and is leased to the City of Pollock for management.

115. The Oahe Unit-South Dakota is another portion of the Missouri Basin Program subject to review at this writing. Initial plans call for full irrigation service to 190,000 acres adjacent to the James River in Spink and Brown Counties. A municipal and industrial water supply of nearly 27,000 acre-feet will be provided from the canal system for 17 municipalities. Fish and wildlife areas will be established and recreation areas developed. The total initial diversion from Oahe will be 444,400 acre-feet; ultimate plans are for irrigation of 495,000 acres of dry land with a corresponding increase in water use. About 13 percent of the right-of-way has been acquired; initial relocations are scheduled for FY 1977. A 20-year construction period is projected.

116. Utilizing funds donated by the 7-Eleven Food Stores Division of Southland Corporation for the purpose of preserving eagle roosting habitat, the National Wildlife Federation acquired 818 acres in fee and 305 acres in conservation easement along the right bank of the Missouri River extending from two to nearly six miles below Fort Randall Dam. These tracts included portions of the Fort Randall Eagle Roost, a location listed in the National Registry of Natural Landmarks. In 1974 the Federation turned the lands and interests over to the U. S. Fish and Wildlife Service as an addition to the National Wildlife Refuge System. The Karl E. Mundt National Wildlife Refuge is now administered by the USF&WLS office at the Lake Andes National Wildlife Refuge.

117. The Gavins Point National Fish Hatchery is located northeast of the Gavins Point Dam near Yankton, SD. The hatchery produces northern pike, walleye, paddlefish, yellow perch, channel catfish, rainbow trout, lake trout, and brown trout for distribution in

South Dakota, Nebraska, and northwest Iowa.

118. Early in this century, Montana Power Company started harnessing the Missouri River in the vicinity of Helena and Great Falls, Montana by installing hydro-power plants. Two power plants are located near Helena at Hauser and Holter dams with a combined installed capacity of 55.4 mw. Below Great Falls five power plants with a combined capacity of 193.4 mw have been constructed at Black Eagle, Rainbow, Ryan, Morony and Cochrane dams. In 1954 the Bureau of Reclamation completed the two million acre foot Canyon Ferry Dam upstream of Helena for irrigation and hydro-power, **over 20,000 acres** of land are under irrigation; installed capacity is 50 mw.

119. The Nebraska Public Power District is proceeding under a Federal Power Commission Preliminary Permit to prepare an application for a license for a hydroelectric power plant referred to as the Boyd County Pumped Storage Project. The site is located adjacent to the Missouri River on the right bank about 15 miles downstream from Fort Randall Dam. In-service dates for the facility are dependent upon further studies of alternatives but a general time frame is estimated for the period 1983 to 1991. The proposed project would consist of an upper reservoir, located on the bluffs of the Missouri River; and a lower reservoir located on the bottomland adjacent to the river. Maximum static head would be about 435 feet and minimum head would be about 349 feet. The upper reservoir would be developed by constructing an earth-fill dam across a natural drainage ravine. The lower reservoir would be developed by construction of dikes approximately 40 feet high on the alluvial plain between bluffs and river. Complete drawdown of the upper reservoir would be equivalent to 18,400,000 kilowatt-hours. Reversible pump turbines in 6 or 8 units would be sized at an estimated one or one and one-third million kilowatts, respectively, to utilize the head differential in converting off-peak to on-peak power. Water required initially to operate the facilities and water required to replace that lost through

evaporation and seepage would be supplied by a pumping station located adjacent to the lower reservoir dike. Water supply to the pumping station would be provided via an intake channel from the Missouri River.

Flood Problems

120. Since completion of the main stem dams, residual problems and opportunities associated with flood control have not been extensive in the reach from the headwaters to Sioux City, covered under this study. Power plant discharges during periods of downstream ice formation have created overbank flow on occasion in the Oahe headwaters below Bismarck. Below Fort Randall where channel capacity has been diminished by delta formation, flooding and also waterlogging have occurred in five of the last eight years. Resolutions by the Public Works Committee in 1960 and 1962 suggested the opportunity to provide flood control, as well as other multiple-purpose uses, by constructing reservoirs above Fort Peck and between Fort Peck and Garrison.

121. Runoff volumes during 1975 have already been described as the largest of record in the basin above Gavins Point. Regulation of these flood flows led to record high storages and moderately high releases. Some consequences previously described were flooding near Bismarck as well as below Fort Randall, and flooding of some private lands within flood control and surcharge zones. The result was a number of suggested changes in reservoir operating policy made by individuals who saw an opportunity to reduce undesirable

effects upon their own property.

Navigation

122. Navigation traffic on the Missouri River utilizing diesel-powered towboats between Kansas City and the mouth dates back to 1915; in 1935 operations were extended to Sioux City. Since that time there have been numerous expressions of interest in extending the navigation project to Yankton and beyond, possibly terminating as far upstream as Fort Benton. The desire for low cost transportation of agricultural products stimulated project support during the early years; more recently, a search for the most economical exploitation of the vast coal reserves in Wyoming, Montana and North Dakota has sparked a companion interest. Opportunities range in scope from extending the head of navigation to Yankton, an additional 73 miles, to adding more than a thousand river miles necessary to reach Fort Benton.

Waterlogging

123. Three locations within the study area have been identified where a rise in the groundwater table has impaired usefulness of

the land - sometimes only intermittently - for agriculture or for human occupancy. Two of these were mentioned in the discussion of flooding problems: the Fort Randall-Niobrara reach and the area downstream of Bismarck. The third area, which has a history of waterlogging problems even though overbank Missouri River flows have not been reported, is in the Buford-Trenton Irrigation District, located just downstream of the mouth of the Yellowstone River.

Bank Erosion

124. Bank erosion along the Missouri River is as old as the river itself; only the form and intensity have varied as man has altered the historical environment of the river. An understanding of the historic past provides the linkage to the current situation and thus provides the necessary basis for possible future action.

The Present River Regime

125. A great deal of data has been obtained over the years in the way of aerial photographs and ground observations relative to flow, stage, sediment load and nature of the channel itself. Thus, information is very briefly summarized in the following paragraphs.

RIVER STAGES

126. Since construction of the dams, essentially all river stages in the open river reaches downstream from the dams have been confined within the channel below the high river banks. Exceptions are: the 10-mile reach upstream from the Niobrara River, where backwater from Niobrara River delta deposits into the Missouri River channel have

caused swamping during the higher than normal releases from Fort Randall Dam; the 29-mile reach downstream from the Yellowstone River which is subject to floods from the Yellowstone; and short reaches near the mouths of the Milk, Knife, Heart, Bad, and Vermillion Rivers, which are subject in occasional years to flooding from tributary runoff. There is essentially no flooding in these reaches as a result of releases from the reservoirs, except for the 10-mile reach above the Niobrara. This includes power peaking releases and flood control releases as rare as 100-year exceedance frequency. This is in contrast to pre-dam conditions when overbank flooding occurred practically every year.

SEDIMENT LOAD

127. The Missouri River reservoirs trap virtually all incoming sediment load and release clear water. Sediment loads in the downstream reaches, therefore, consist of bed material load derived from the river bed, and bed material and wash load derived from eroded river banks. Tributary inflows make occasional contributions of short duration. This is in contrast to pre-dam conditions when relatively high sediment loads, contributed from upstream, were transported through the reaches. Furthermore, during times of flood, some of the sediment load had the opportunity to deposit and form new flood plain lands, which is not now the case with the reservoirs in operation. Annual deposition in the lakes is given in Table B-15.

VALLEY DESCRIPTION

128. The river valley geometry is summarized in Table C-2. Except for the reach below Gavins Point Dam, the river occupies a substantial proportion of the valley width between bluffs. Within the narrow valley, the river channel crosses from side to side, alternately hugging one bluff contact or the other. In the wider valley below Gavins Point Dam, the river channel is more free to migrate and has formed the classical alluvial river meander pattern. Figures C-10 through C-16 show the river channel locations in the years 1890,

1944 and 1974 in Gavins Point to Ponca reach. It is apparent that in the past 85 years the river channel has continually migrated within a meander belt of one to three miles in width.

TABLE C-2
MISSOURI VALLEY GEOMETRY
IN OPEN RIVER REACHES

Reach	Open River Length Miles	Valley Width Miles	River Channel Width Between High Banks Feet	Percent Valley Occupied by Channel Percent
Ft. Peck to Garrison	190	3.1	1,100	7
Garrison to Oahe	87	1.7	2,100	25
Oahe to Big Bend	5	0.6	1,000	30
Ft. Randall to Gavins Point	43	1.4	2,100	30
Gavins Point to Ponca State Park	58	7-10	2,500	7

VALLEY LAND USE

129. The use of valley lands landward from the high river banks is predominately agricultural. Much of the remaining forest in the river bottoms is as yet uncleared land adjacent to the river banks. At several locations roads and bridge approaches near the river are threatened by bank erosion. In all the reaches there is a continuing trend, stimulated by the virtual elimination of flooding, for private homes and recreational facilities to be constructed along the banks.

THE RIVER CHANNEL

130. The total river channel area between high banks is occupied by three characteristic areas, the normal flow channel, high sand bars, and islands. The normal flow channel lies in a sandy bed that has been degrading slowly since closure of the upstream dam.

Figure C-10 GAVINS POINT DAM TO PONCA STATE PARK, NE.
HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 804-811

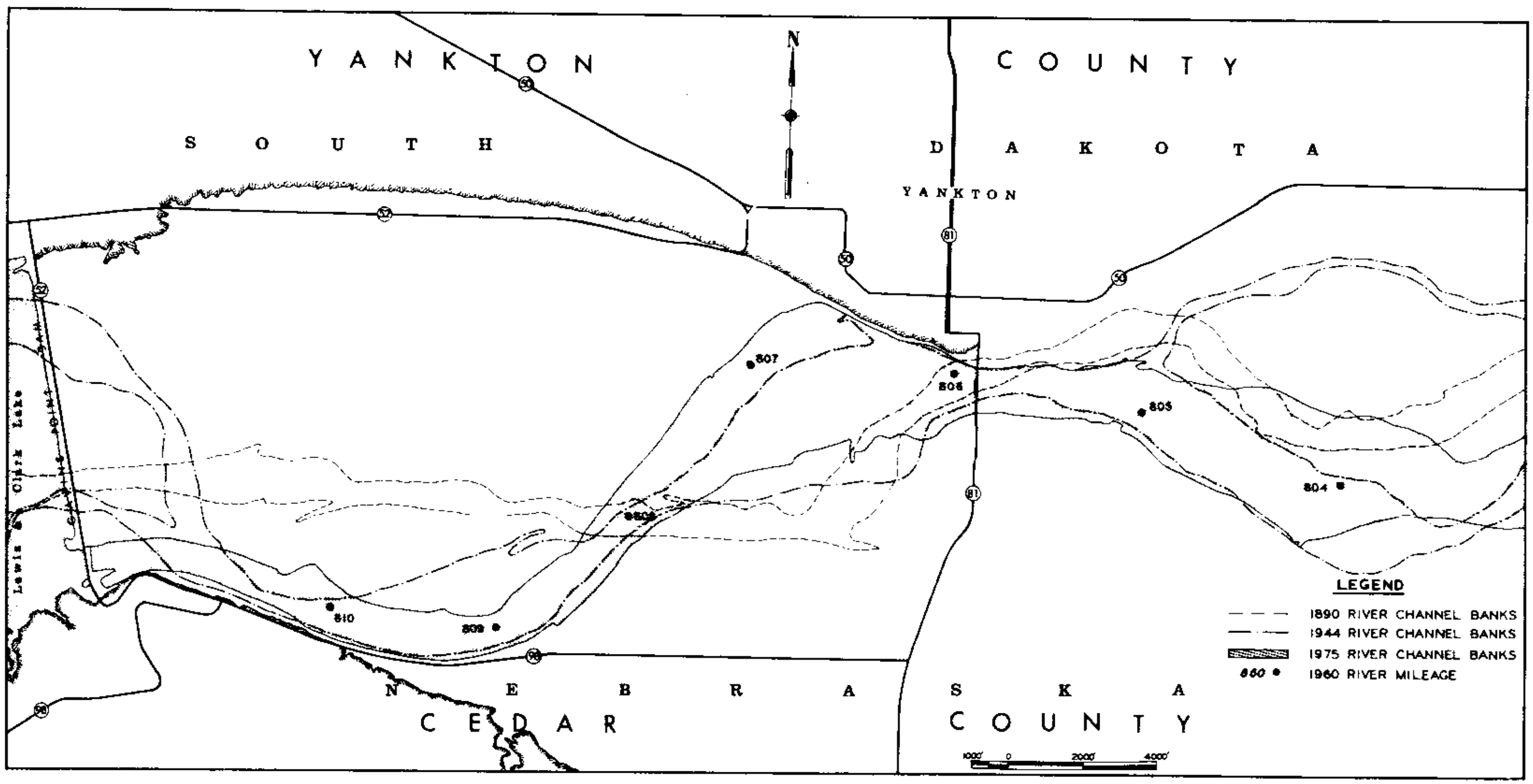


Figure C-11 GAVINS POINT DAM TO PONCA STATE PARK, NE.
HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 796-803

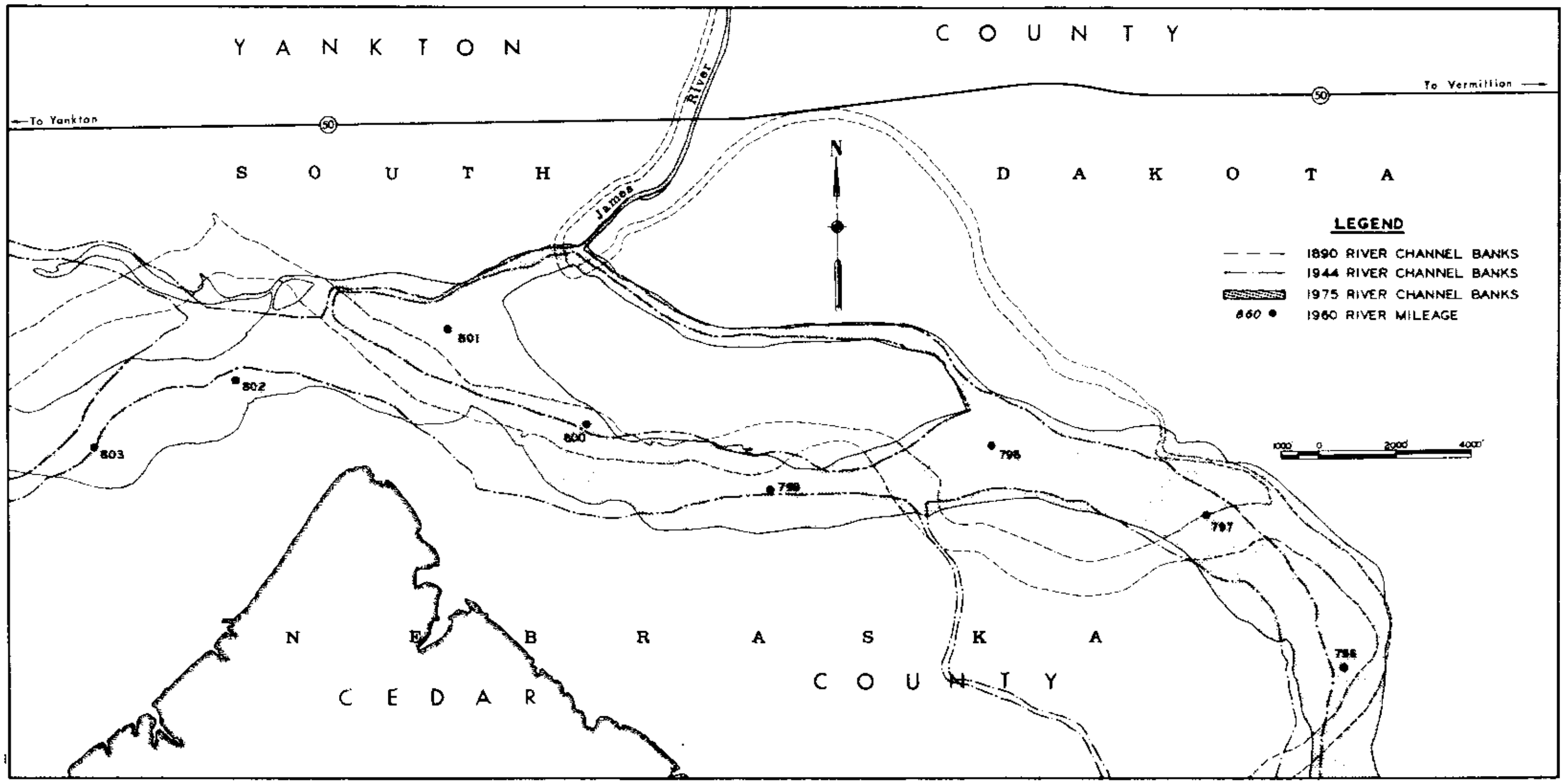


Figure C-12 GAVINS POINT DAM TO PONCA STATE PARK, NE.
HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 788-795

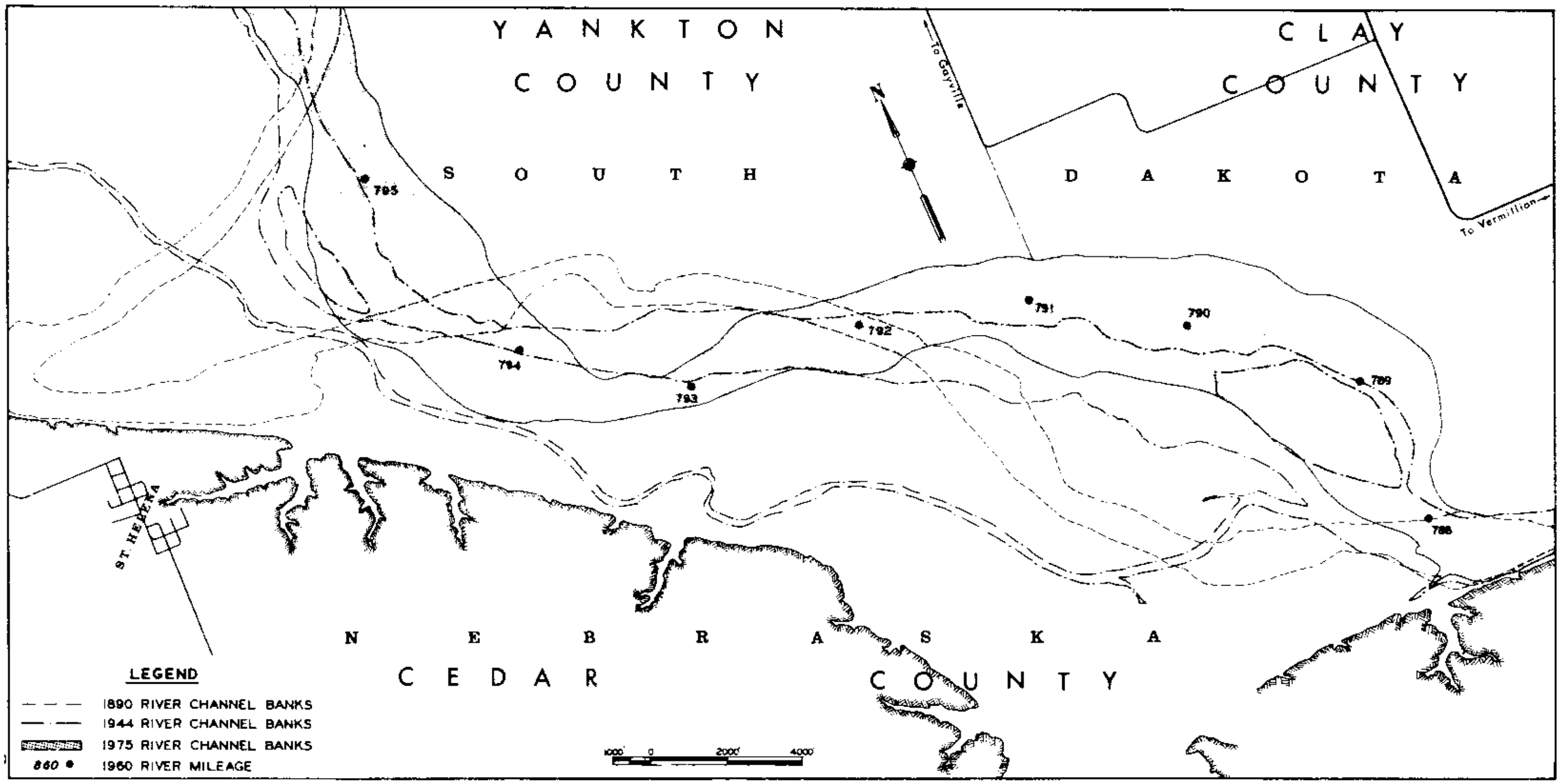


Figure C-13 GAVINS POINT DAM TO PONCA STATE PARK, NE.
HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 780-787

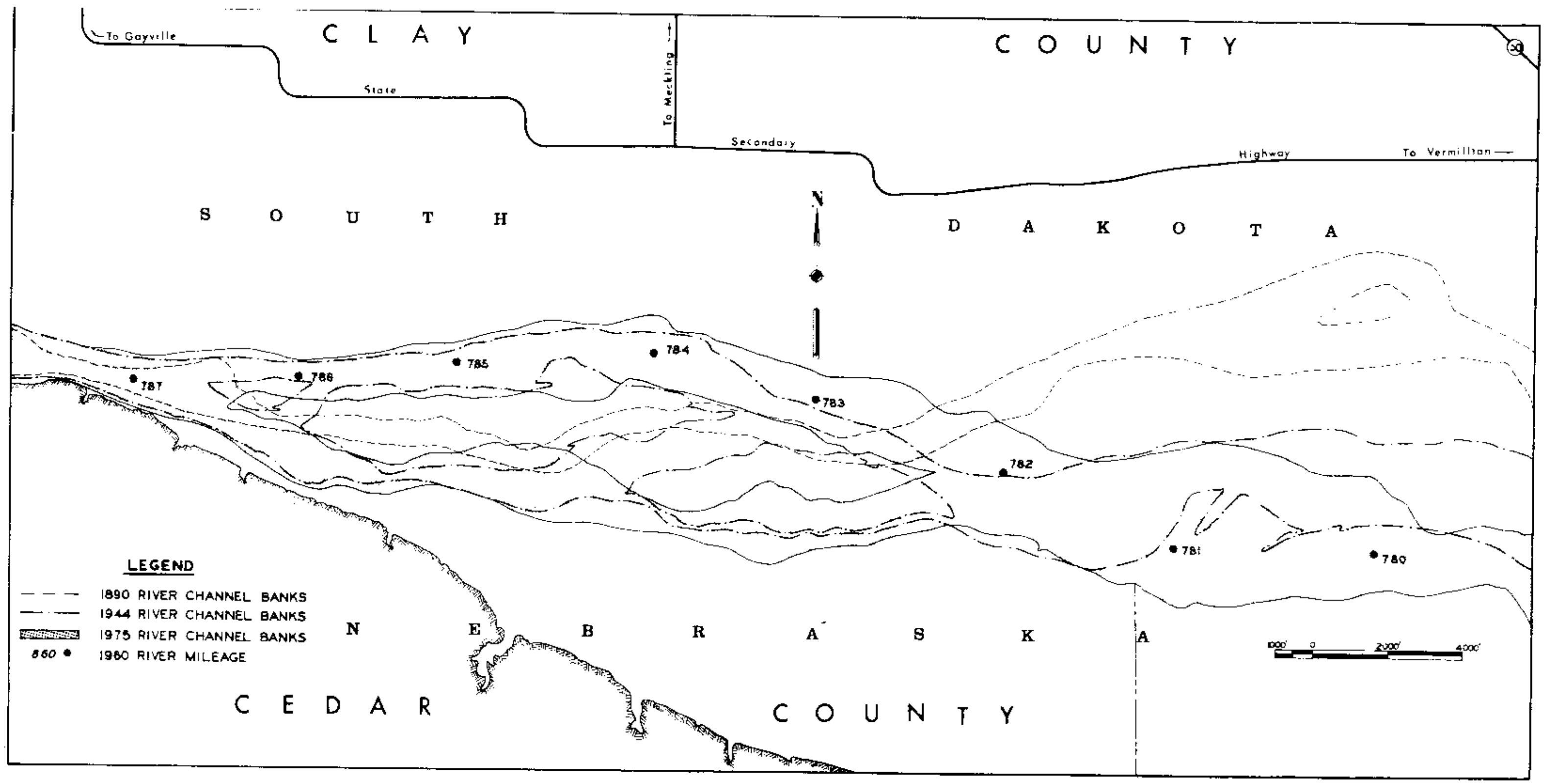


Figure C-14 GAVINS POINT DAM TO PONCA STATE PARK, NE.

HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 770-779

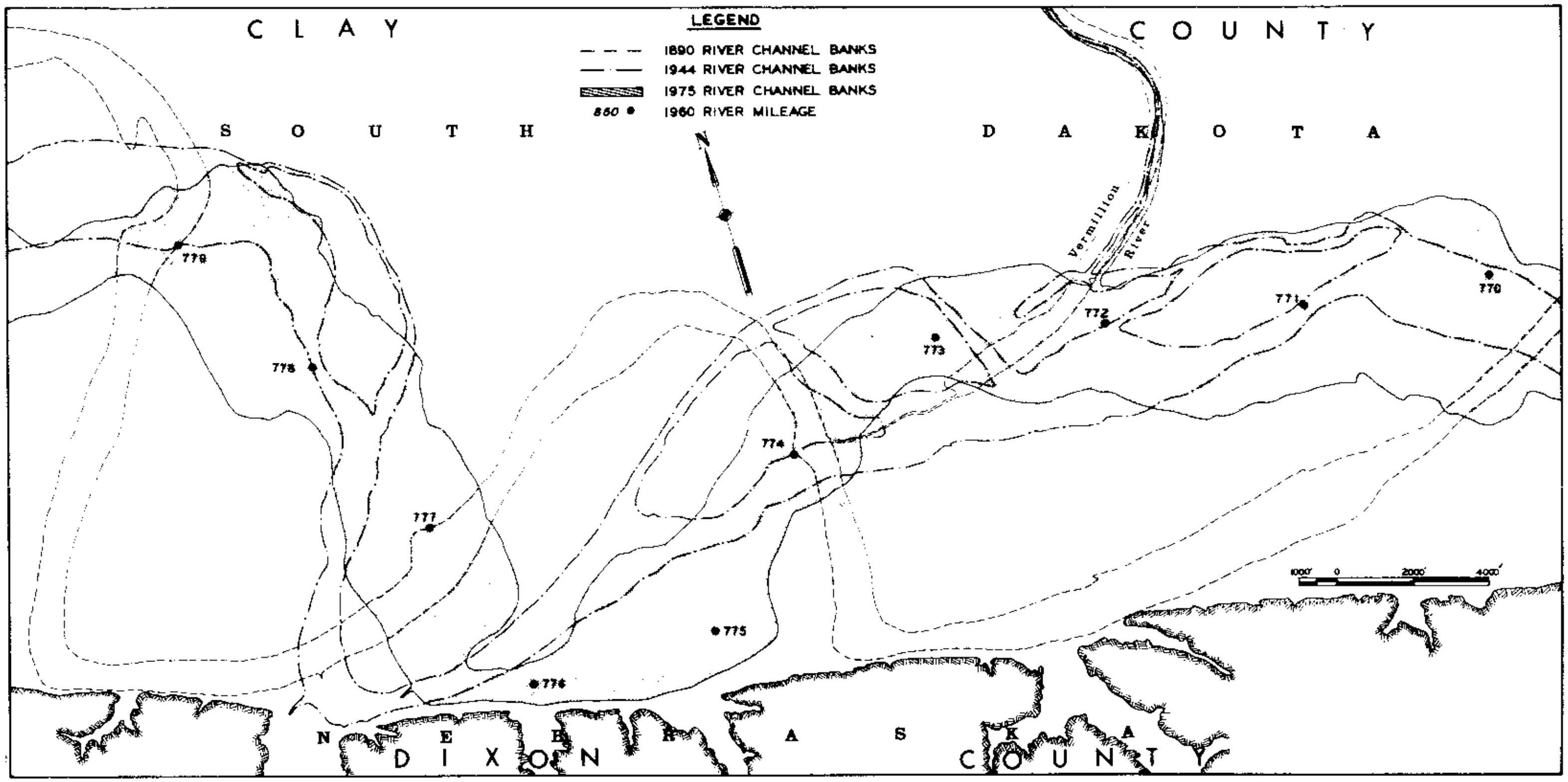


Figure C-15 GAVINS POINT DAM TO PONCA STATE PARK, NE.

HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 760-769

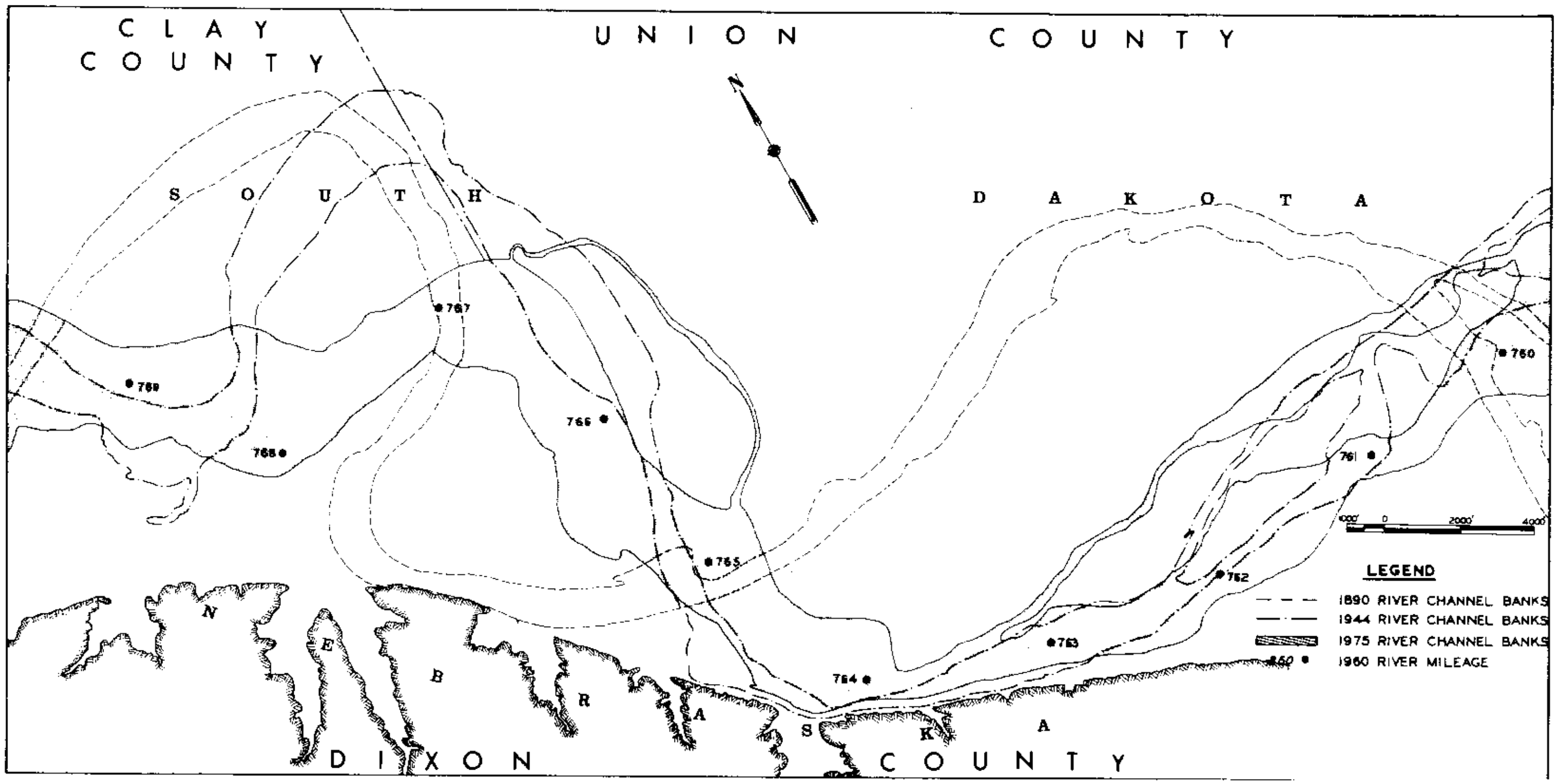
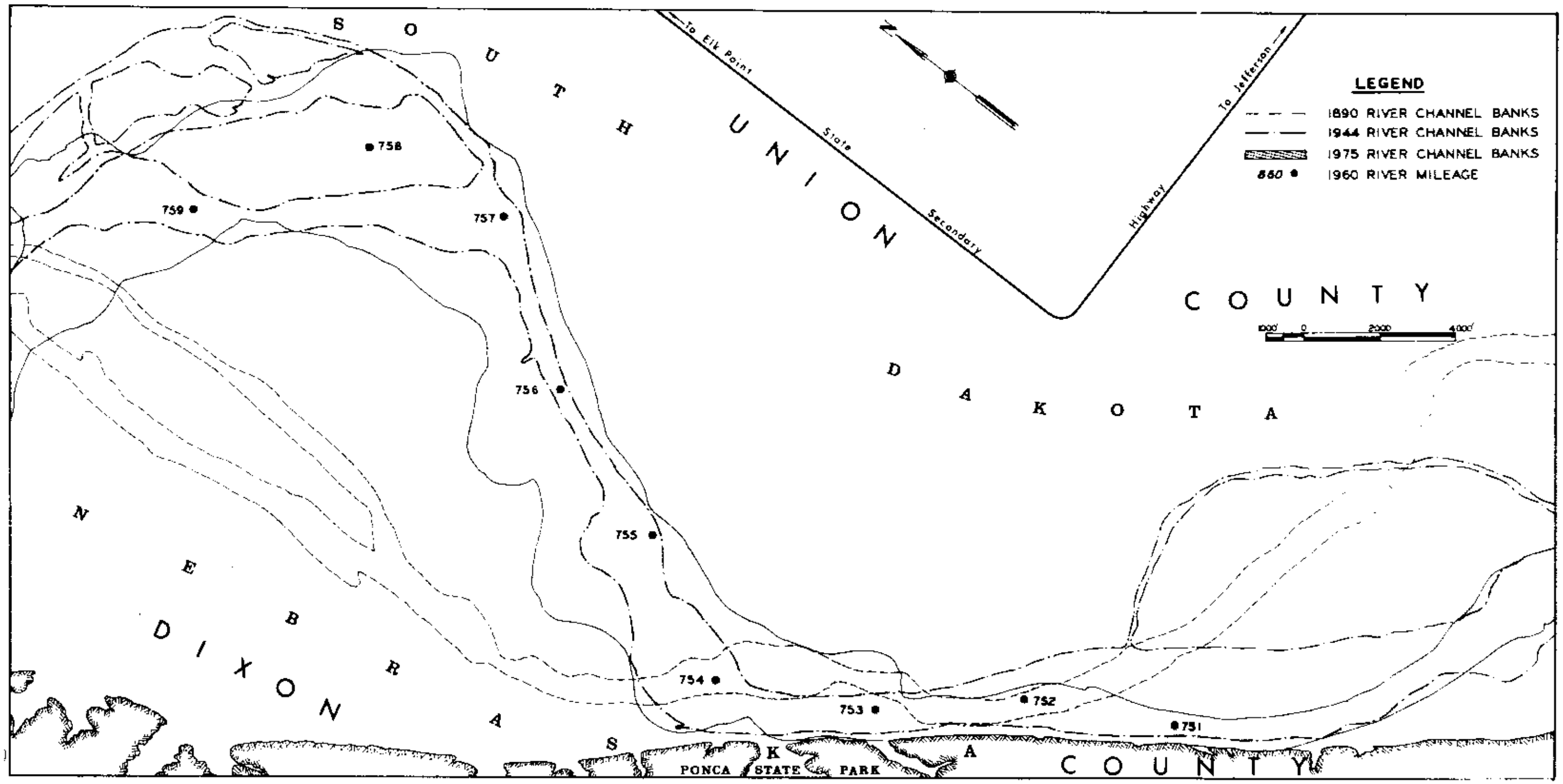


Figure C-16 GAVINS POINT DAM TO PONCA STATE PARK, NE.
HISTORICAL CHANNEL LOCATIONS -- RIVER MILE 751-759



As it degrades, it also meanders between high banks and is split into multiple channels by sand bars and islands. In a continuation of typical alluvial channel processes, valley islands adjacent to the high banks are eroded and converted to river channel. Between the high banks, bar areas give way to the channel and channel areas become bars. Main channels fill in to become inactive chutes, and secondary channels open up to become main channels. The location of the normal flow channel continually shifts in response to these processes, resulting in a gradual widening of the area occupied by channel, sand bars, and islands.

DEGRADATION RATES

131. A special study was made of the normal flow channel in the degrading reach downstream from Gavins Point Dam to Ponca State Park, Nebraska. Plate C-1 compares profiles of the water surface for 30,000 cfs, of the channel thalweg, and of the mean bed, for year 1955 when Gavins Point Dam was closed and for year 1974. The total degradation during that period, as indicated by lowering of the water surface, varies from 7.5 feet just below the dam to three feet about six miles downstream and continues at three feet on downstream to Ponca State Park. The rate of degradation just below the dam has been about 0.3 feet per year. Lateral shifting of the normal flow channel location is illustrated in Plates C-2 through C-5, which compare 1955 and 1974 channel cross sections in the reach. These cross sections were analyzed to determine how the dimensions of the normal flow channel have changed during the period while it was shifting laterally and degrading vertically. Plate C-6 compares the water surface width and the mean water depth for 1955 and for 1974, at the various river ranges from Gavins Point Dam downstream to Ponca, for the portion of the river channel below the stage for 30,000 cfs which has been a normal discharge during the navigation season. Plate C-6 shows that neither the water surface width nor the mean depth are appreciably different between 1955 and 1974. This seems to indicate that in spite of the shifting

of the channel location and the continuing degradation of the water surface and the river bed, the dimensions of the normal flow channel have tended to remain about the same. On the other hand, the riverine area between high banks has steadily widened due to high bank erosion.

SAND BARS AND ISLANDS

132. The high sand bar areas are 10 to 15 feet below the tops of high banks. Their surface ranges from bare sand, to small willows, to a more mature vegetative succession, depending on the elevation of the bar above the normal range of water levels and how recently the bar was deposited. Over a period of several decades all bar areas between high banks are potentially subject to being destroyed by the shifting channel, only to be replaced by deposition in other locations. Islands are areas about as high as the high banks, separated from the high banks by river channels or sand bars. Table C-3 provides data on the principal islands in each reach:

TABLE C-3 DATA ON ISLANDS IN OPEN RIVER REACHES

Reach	Number of Islands	Total Acres
Fort Peck to Garrison	5	1,600
Garrison to Oahe	3	850
Oahe to Big Bend	1	100
Fort Randall to Gavins Point	7	1,800
Gavins Point to Ponca State Park	2	2,000

The banks of the islands are subject to erosion just as the high banks adjacent to valley lands. The islands have been eroding over the years and will continue to erode and eventually disappear unless preventive measures are taken. In the erosion process the high lands on the islands are converted to river channel and high sand bar areas.

The Bank Erosion Process

133. In the natural river prior to the construction of the reservoirs, there was balance over the years between the destruction of valley lands by erosion of the high banks and the building of new valley lands by sediment deposited during the floods. This process resulted in a continual migration of the river channel within the Missouri River Valley as illustrated by Figures C-10 through C-16 for the Gavins Point reach. Due to the balance between the erosion and the deposition processes, however, there was no long term net loss of high valley lands.

134. Since the dam closures, the operation of the reservoir system has eliminated both the floods and the sediment that were essential for the building process. On the other hand, the erosion of high banks continues. Consequently, bank erosion results in a permanent net loss of high valley lands that are never replaced elsewhere in the valley as in the era before the reservoirs. High valley lands are being converted to river channel and sand bar areas, while the width between high banks continues to widen. This process, unless halted, would eventually transform the present river into a wide area of sand bars and channels, occupying an increasing proportion of the valley width between bluffs.

<u>BANK EROSION RATES</u>

135. Aerial photographic surveys taken over the years have been analyzed to obtain estimates of valley lands lost in each reach. The estimates include only areas that were judged to be suitable for cultivation, for building sites, or for municipal or recreation facilities. They do not include the erosion of sand bar areas or low vegetated areas adjacent to the channel and riverward of the high river banks. The results of the post-dam period are summarized in Table C-4 which shows the total loss of valley land in each reach since dam closure. The variations in bank erosion rates with distance downstream from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams are represented in Table C-5. Figure C-17 shows graphic

comparisons of total valley lands lost to erosion versus distance downstream from the dam for the Garrison, Fort Randall, and Gavins Point reaches.

TABLE C-4 EROSION OF VALLEY BOTTOM LANDS SINCE DAM CLOSURE

				Erosion Losses Since Closure		Estimated Future Losses	
	Miles of Open River	Miles of Erodible Bankline	Period	Total Acres Lost	Acres Per River Mile Per Year	Acres Per Year	Acres Per River Mile Per Year
Gavins Point Dam to Ponca State Park, NE (Miles 752.6-806.3)	53.7	103	1955-1975	3760	3.50	200	3.72
Fort Randall to Niobrara (Miles 843.7-880)	36.3	56	1952-1975	1080	1.29	30	0.83
Big Bend Dam to Fort Randall	0	None	1963-1975	None	None	None	None
Oahe to Big Bend (Miles 1072.3-1067.3)	5	2	1958-1975	Negligible 1/	Negligible 1/	2 1/	0.4 1/
Garrison Dam to Bismarck (Miles 1310-1389)	79	109	1953-1975	1772	1.01	75	0.95
Fort Peck Dam to the Mouth of the Yellowstone River (Miles 1582.1-1771.6)	190	368	1937-1975	7445	1.03	130	0.69

1/ Erosion in this reach is concentrated in one area, where a potential loss of 100 acres exists over the next 50 years.

136. The results of all aerial photograph comparisons for both pre-dam and post-dam periods in the reaches downstream from Garrison, Fort Randall, and Gavins Point Dams are presented in Tables C-6 through C-8. These data indicate that erosion rates since dam closure have been substantially less than pre-dam rates in the Garrison and Fort Randall reaches. This has not been the case in the Gavins Point reach for probable reasons that will be discussed in paragraph 147.

137. Only one aerial photographic comparison (years 1938 and 1975) was made for five sample subreaches in the 190 miles of river below Fort Peck Dam. The results are shown at the bottom of Table C-4.

138. In the five-mile reach downstream from Oahe Dam, high bank erosion has been negligible to date due to a long bluff contact on the left and a long mid-channel bar on the right that has buffered

TABLE C-5 EROSION RATES WITH DISTANCE DOWNSTREAM FROM DAMS

Miles Below Dam	Existing Power Peaking Fluctuations, Ft	Erosion Rate Acres/Mile
Below Gavins Point Dam (1959-1975)		
0 to 20	None	42.4
20 to 40	None	75.4
40 to 58	None	100.5
Below Fort Randall Dam (1953-1975)		
0 to 10	11.0 - 6.7	17.4
10 to 20	6.7 - 5.4	41.9
20 to 30	5.4 - 3.2	19.4
30 to 36	3.2 - 2.5	24.7
Below Garrison Dam (1966-1975)		
0 to 20	10.5 - 4.5	8.0
20 to 40	4.5 - 1.5	22.0
40 to 60	1.5 - 0.8	20.5
60 to 79	0.8 - 0.5	18.0
Below Fort Peck Dam (1938-1975)		
32 to 47	2.0 - 1.5	10.5
51 to 75	1.5 - 1.0	18.0
83 to 93	Negligible	11.0
120 to 142	Negligible	26.0
166 to 187	Negligible	29.0

the right bank from the main flow. This situation is shown on Plate C-20. In recent years, however, the bar **has eroded at the** downstream end, which is bringing under attack about one mile of the right bank along the upstream outskirts of Fort Pierre. It is estimated that the situation, if not corrected, will result in the loss of about 100 acres over the next 50 years. This is reflected in the future estimate shown for the Oahe reach in Table C-4.

139. Study of aerial photographs from over the years reveals that bank erosion does not occur uniformly along the erodible bank lines at the average rates indicated in Table C-4. Within each of the open river reaches the destruction of land in any one year is usually

Figure C-17 EROSION LOSS OF VALLEY LANDS AND POWER PEAKING STAGE FLUCTUATIONS DOWNSTREAM OF MISSOURI RIVER DAMS

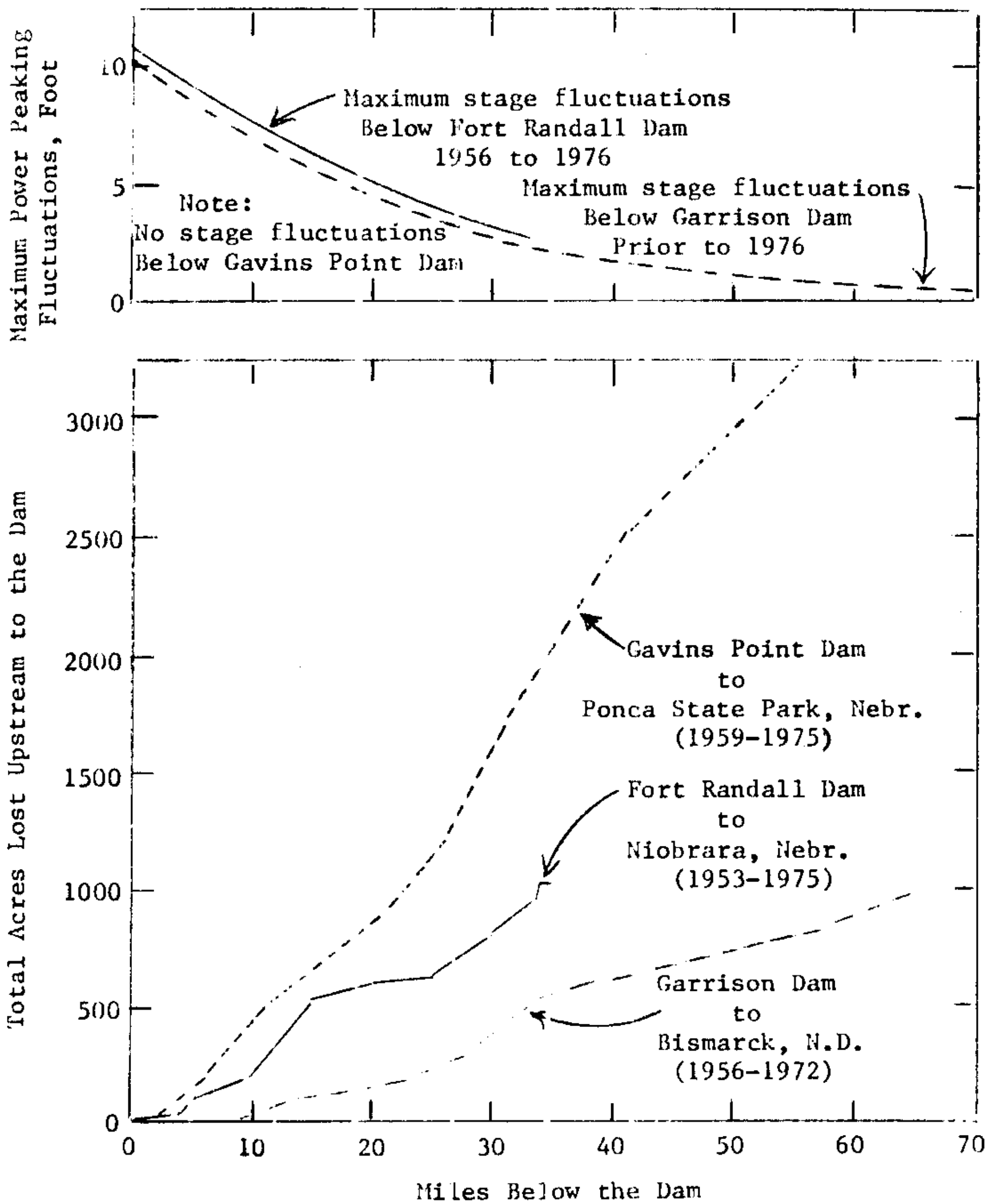


TABLE C-6 MISSOURI RIVER BANK EROSION LOSSES
GARRISON DAM TO BISMARCK, NORTH DAKOTA 1/

Period	Time, Years	Total Erosion Loss, Acres	Erosion Rate Acres/Year	Erodible Bankline, Mi 2/
1938-1946	8.0	1394	174	139
1946-1954	8.0	2167	271	139
1954-1956	2.0	215	108	139
1956-1958	2.0	183	92	139
1958-1960	1.8	192	106	139
1960-1964	4.2	355	85	139
1964-1968	4.3	271	63	132
1968-1972	4.0	265	66	130
1972-1974	1.7	134	79	111
1974-1975	1.1	76	69	109
Pre-Dam Conditions				
1938-1954	16.0	3561	222	-
Post-Dam Conditions				
1954-1975	21.1	1692	80	-

1/ Reach extends between 1960 river miles 1310 to 1389, for a total distance of 79 river miles.

2/ Figures represent actual miles of erodible bankline between river miles 1310 and 1389, and deducts for bluff contacts (19 bankline miles) and areas protected by bank stabilization works constructed since 1964.

TABLE C-7 MISSOURI RIVER BANK EROSION LOSSES FORT RANDALL DAM TO NIOBRARA, NEBRASKA 1/

Period	Time, Years	Total Erosion Loss, Acres	Erosion Rate Acres/Year
1946-1953	7.0	945	135
1953-1956	3.1	246	79
1956-1961	5.0	290	58
1961-1966	5.0	230	46
1966-1969	3.3	128	39
1969-1974	4.8	111	23
1974-1975	1.1	52	47
Pre-Dam Conditions			
1946-1953	7.0	945	135
Post-Dam Conditions			
1953-1975	22.3	1058	47

1/ The study reach extends between the mouth of the Niobrara River to Fort Randall Dam, 1960 river miles 843.7 to 880, for a total distance of 36.3 river miles. Sixteen (16) bankline miles of the reach are in contact with high bluffs (4.5 miles on the left bank and 11.9 miles along the right bank).

TABLE C-8 MISSOURI RIVER BANK EROSION LOSSES GAVINS POINT DAM TO PONCA, NEBRASKA 1/

Period	Time, Years	Total Erosion Loss, Acres	Erosion Rate Acres/Year
1930-1945	15.00	3062	204
1945-1956	11.00	2179	198
1956-1969	10.33	1656	160
1970-1972	2.67	784	293
1972-1974	1.83	448	244
1974-1975	1.08	277	257
Pre-Dam Conditions			
1930-1956	26.00	5241	202
Post-Dam Conditions			
1956-1975	18.99	3570	188

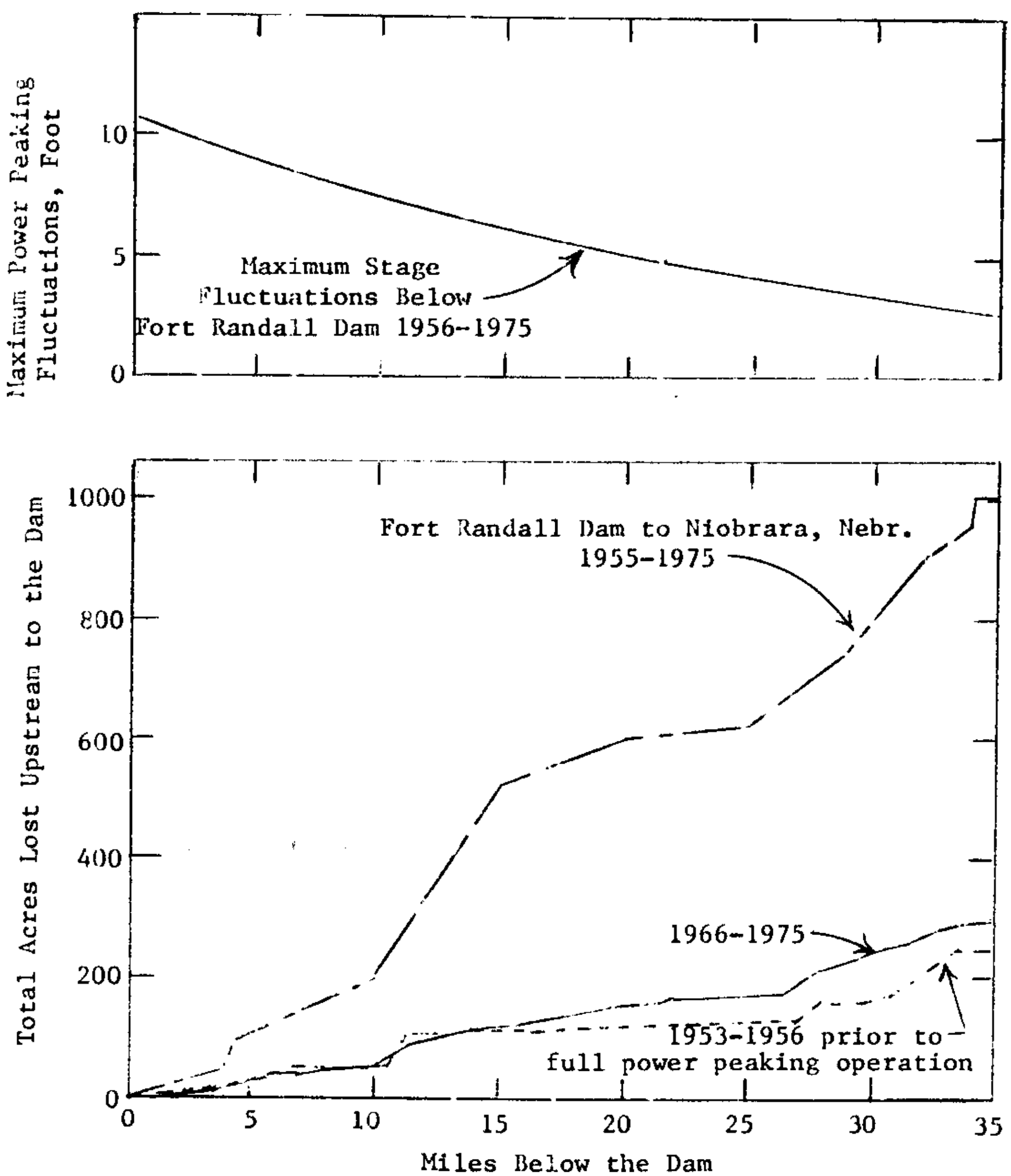
1/ The study reach extends between 1960 river mile 752.6 (Ponca State Park, Nebraska) to river mile 806.3, which is approximately one-half mile upstream from Yankton, South Dakota, for a total distance of 53.7 river miles. Four (4) miles of the above reach are in contact with high bluffs. The reach between river mile 806.3 and mile 811.1 (Gavins Point Dam) is not included in the above figures.

concentrated over a few thousand feet of bankline in one or a few locations. These locations of active erosion shift from place to place from year to year. Although the long-term annual acreage loss in each reach can be estimated, it is not possible to pinpoint specific locations and make future erosion predictions. What can be predicted is that over the years every stretch of erodible bankline is potentially subject to active erosion. This is borne out by Figure C-18 in which the accumulative plots at Fort Randall tend toward straight line fits after over 20 years of bank erosion experience.

140. From the point of view of the individual riparian landowner, this erosion process is not a predictable and consistent annual occurrence, but represents a real threat that in any given year he may suffer a major loss and disruption of his operations. The elimination of the annual flood threat has encouraged a more intensive use of these lands, therefore, private investments in such improvements as sprinkler irrigation are continuing to rise. Any erosion or meandering of the channel causes major problems and complaints.

141. The continuing threat of bankline erosion is a particular problem for those activities where proximity to the river bank is either desirable or necessary. These include irrigation intakes, summer homes, and recreation facilities. The trend toward all these developments has accelerated with the elimination of the flood threat. The preservation of forest land is of special concern since much of the remaining uncleared woodlands in the Missouri River bottoms are concentrated near the river banks. In planning the use of riverside areas it is difficult to make an allowance for bank recession on account of the unpredictability and non-uniformity of the process. In the Gavins Point reach, for example, the future erosion rate estimate presented in Table C-4 translates into about 15 feet of bank recession per year, if the average rate were uniformly applied. In reality, however, a stretch of bankline might remain stable for

Figure C-18 EROSION LOSS OF VALLEY LANDS AND POWER PEAKING STAGE FLUCTUATIONS DOWNSTREAM OF FORT RANDALL DAM



years and then cut back several hundred feet in one season.

142. Examination of the data in Tables C-6, C-7, and C-8 proves that bank erosion was a natural occurrence under pre-dam conditions and has continued since the dam closure. What is different under post-dam conditions is that erosion losses of valley lands are no longer replaced. This permanent loss of high valley lands and their conversion to low sand bar areas is clearly the consequence of construction and operation of the Missouri River System. The loss is particularly significant in the Dakotas where the Missouri River valley between high bluffs averages only about 1-1/2 miles in width and where there remain only a few miles of bottom lands that are not inundated by the main stem dams.

FUTURE EROSION RATES

143. Based on the interpretation of trends indicated by the data in Tables C-6, C-7, and C-8, future bank erosion rates were predicted for the Garrison, Fort Randall, and Gavins Point reaches. These results were used in estimating future rates for the Fort Peck and Oahe reaches. The results are shown in Table C-4.

EFFECTS OF POWER PEAKING ON BANK EROSION

144. The question arises whether power peaking has accelerated bank erosion. The evidence is that it has not, except for an initial adjustment in bank slope that will be discussed below. Table C-5 summarizes observed rates of bank erosion over periods of many years at various distances downstream from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams. Table C-5 also shows the present range of power peaking fluctuations at the various distances downstream from the dams other than Fort Peck. Similar information is presented graphically in Figure C-17 which plots cumulative land losses against distance downstream from each dam. The present range of power peaking fluctuations is also plotted against distance downstream on Figure C-17. Figure C-18 is a similar plot for the Fort

Randall reach only, comparing land losses for the period 1953 to 1956 while the turbines were still being installed, with the period 1966 to 1975 when the powerplant had full peaking capability. Study of Table C-5 and Figures C-17 and C-18 indicates that:

- Bank erosion rates have been greatest below Gavins Point Dam where there have been no appreciable power peaking fluctuations.

- Downstream from Fort Peck, Garrison, and Fort Randall Dams the bank erosion rates near the dam are no greater than overall rates in the reach, although the power peaking fluctuations have been greatest at the dams and have decreased in the downstream direction. This can be seen in Figure C-17 where a straight line fitting an accumulative plot indicates the average uniform erosion rate through a reach, while a plotted slope flatter than the straight line fit indicates an erosion rate less than the average.

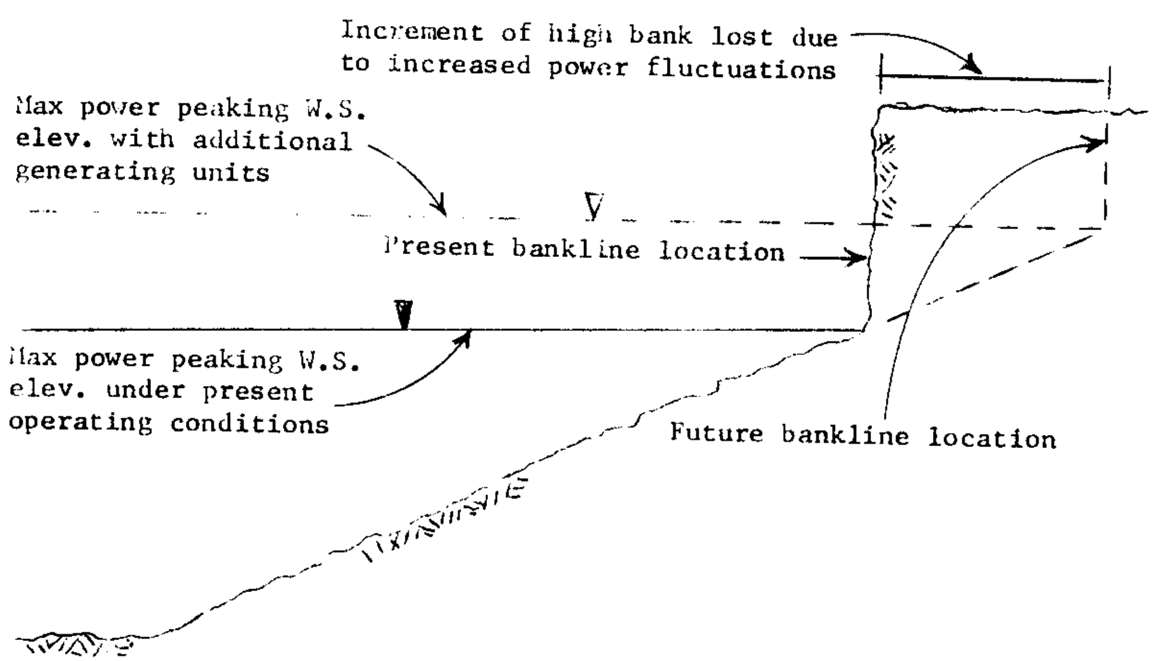
- Downstream from Fort Randall Dam Figure C-18 indicates that the land losses for the four-year period 1953-1957, while full power peaking capacity had not been installed, were nearly as great as for the ten-year period 1966-1975 when the Fort Randall power plant had full power peaking capability.

It is concluded that power peaking has not significantly affected on-going bank erosion rates, except for the initial adjustment in bank slope.

145. Although power peaking has not affected on-going bank erosion rates below the Missouri River dams, the rapidly fluctuating stages have caused an initial recession of the high bankline due to instability of the upper bank slopes. Figure C-19 illustrates the observed effect of daily fluctuation in the river water level on the slope of the bank profile. Within the range of fluctuating water levels, the bank material slumps to form a relatively flat sloping berm. This is an adjustment to achieve slope stability under the regimen of daily seepage and drainage of water into and out of the sandy bank material. Above the maximum limit of the water level fluctuations the river bank is typically vertical.

Once this bank configuration is formed in response to the regimen of fluctuating river levels, it remains relatively stable until conditions are upset, either by riverbed scour that undermines the sloping berm, or by a change in the pattern of water level fluctuations. If the maximum level of the fluctuations increases, the vertical bank will slough to extend the sloping berm to the higher elevation. The resultant loss of land adjacent to the vertical bank is illustrated in Figure C-19. Downstream from Fort Peck, Garrison, and Fort Randall Dams it has been observed that the slope of the banks within the vertical range of the power peaking fluctuations now averages about 1 on 10, vertical to horizontal.

Figure C-19 EFFECT ON BANK PROFILE OF ADDITIONAL POWER PEAKING STAGE



146. Downstream from Garrison Dam where increased power peaking capacity but no reregulation of fluctuating releases is proposed, the extended ranges of daily stage fluctuations are expected to induce new adjustments in bank slopes at elevations above the present maximum stage. Assuming the bank adjusts to a stable slope of 1 on 10, vertical to horizontal, and utilizing computed increases in

power peaking stage fluctuations at various distances downstream from the dam, it has been estimated that the increased peaking capacity would induce a new loss of about 190 acres adjacent to about 64 miles of erodible bank line in the first 40 river miles below the dam. These would be one-time losses, occurring during the first months when the new power peaking regimes go into effect.

PRINCIPAL FACTORS AFFECTING BANK EROSION

147. For conditions on the Missouri River there are probably several factors more significant than power peaking fluctuations that affect bank erosion rates below the dams:

- Water Supply Although the river reach below each dam has about the same slope and about the same bed and bank material, there are significant differences in the comparative volume of water moved, affecting the intensity of bed movements and, therefore, the attack on the banks. The long-term average releases from Fort Peck, Garrison, and Fort Randall are 33 percent, 83 percent, and 93 percent, respectively, of the Gavins Point release.

- Bluff Contacts Flow along long bluff contacts tends to stabilize the channel alignment and reduce bank erosion rates. The Gavins Point and Fort Peck reaches have little bluff contact, compared with 24 percent of the channel length in the Garrison reach and 44 percent in the Fort Randall reach lying against the bluffs on one side or the other.

- Armoring Bed armoring contributes to channel stability by reducing the intensity of bed sediment movements. This might be one explanation for the reduced rates of bank erosion in the first five to ten miles below each dam where the degradation and the segregation process are accumulating an armor layer at the bed surface.

The reasons for the substantially greater erosion rates below Gavins Point compared with the upstream reaches is probably the greater discharge, coupled with little bluff contact downstream from Yankton.

148. The preceding paragraphs have outlined the nature of the erosion problem in physical terms before and after construction of the Main Stem Reservoir System. There is no doubt that the reservoir system has altered physical conditions or that the nature of bank erosion in terms of consequences has been significantly altered. Similarly, the reservoir system itself constitutes a system of dam and reservoir elements integrated hydraulically, hydrologically, and electrically. Accordingly, the river channels connecting these elements are also inseparable components of the total system. It is not logical to view them as separate and discrete increments with problems derived from the rest of the system.

149. The Congress has in at least three legislative actions espoused a policy of examining system effects in toto rather than piece-meal. Sections 122 and 216 of the 1970 Flood Control Act affirm the Congressional policy that detrimental effects of projects should be evaluated and mitigated to the greatest extent possible and that in the wake of project completion reviews may well be in order to remedy problems that have arisen. In more direct action, the Congress has recognized the erosion problems associated with the Missouri River System through authorization of remedial measures in the 1963 Flood Control Act, PL 88-253, by Section 32 of PL 93-251 and by Section 161 of PL 94-587, the Water Resources Development Act of 1976.

150. This rather lengthy discussion of bank erosion problems has been presented in order to provide the basis for formulating remedies presented later in this report. In essence, bank erosion issues addressed in this investigation are not separable problems to be addressed in the manner which would be appropriate during conventional water resource formulation. The preponderance of the evidence and the expressions by the Congress place this problem as an integral part of an existing large reservoir system and solutions eventually must become a part of the systems management and operation.

Hydro-Power

151. The power output of the Missouri River main stem hydro plants is marketed on a wholesale basis by the Bureau of Reclamation throughout a marketing area approximating that of the Mid-Continent Area Reliability Coordination Agreement (MARCA). Membership in MARCA is made up of all electric utilities serving bulk power supply requirements of eastern Montana, the entire States of North Dakota, Nebraska, Minnesota, and Iowa, western Wisconsin, and most of South Dakota except for a small western portion. The Bureau is a member of this group of utilities, all of which are strongly interconnected and operate on a coordinated basis to interchange power, share reserves, and assist each other in emergencies. Thus, main stem hydro-power is an integral part of the power supply for the MARCA Region.

Current Development

152. Pertinent data for the generating units presently operational at the six main stem dams are given in Table B-15; two Bureau projects in the Basin also have hydro-power installations.

	Number of Units	Nameplate Capacity - MW	Energy 7/75-6/76 Million KWH
Corps of Engrs	36	2,048	14,527
Bureau of Reclamation			
Canyon Ferry	3	50	508
Yellowtail	4	250	1,327
Subtotal	7	300	1,835
System Total	43	2,348	16,362

153. The 1975 net generation in the MARCA area was 79,897,000 kwh. Sources of this generation were:

Coal - 40%	Nuclear - 25%
Oil - 2%	Hydro - 25%
Gas - 8%	Other - negligible

Projected Demand

154. Projected power needs in the MARCA Region are prepared annually and submitted jointly by the member systems to the Federal Power Commission pursuant to FPC Docket R-362. The most recent projection was submitted in April 1976 and covers the time period 1976-1995. MARCA system peak loads are projected to increase during this time period from approximately 16,000 megawatts in 1976 to nearly 48,500 megawatts by 1995. Assuming that required generating capability includes a 15 percent reserve margin, approximately 37,500 megawatts of new capacity will have to be added within the MARCA Region during the next 20 years.

155. Some of the required new capacity is now under construction, but much remains to be committed. Baseload requirements can be met by coal-fired or nuclear steam-electric plants, intermediate loads by conventional hydro or older steam-electric stations, and peak loads by hydro plants of the conventional or pumped storage type and by combustion-turbines. The output of the Missouri River main stem hydro plants can be utilized to serve a portion of the future intermediate and peaking load requirements. In addition, it has been estimated by the FPC that approximately 1500 megawatts of new pumped storage could be utilized throughout the MARCA Region in the period 1980-1985 and another 4500 megawatts during the period 1985-1994. Projections provided by the Electric Power Survey Committee of the Edison Electric Institute, October 1975, indicate that the distribution of net generation would approximate the following by 1985.

Coal - 63%	Nuclear - 26%
Oil - 2%	Hydro - 7%
Gas - negligible	Other - negligible

Scheduled additions within the MARCA area as of October 1975 include 20 conventional thermal steam turbine generators of 9,703 mw; one nuclear steam turbine unit of 1193 mw; two gas turbine generators of 88 mw; and four hydraulic conventional units of 45 mw.

Instream Sites

156. The study reach between Sioux City, Iowa and Three Forks, Montana has a fall of 2,925 feet in a distance of 1,583 miles. Forty percent of this drop occurs in the first 200 miles, between Three Forks and Great Falls, Montana. A third of this is developed by Federal, State, and private power, recreation, and water supply dams. From Great Falls, Montana downstream to Sioux City, Iowa, is a river reach 1,375 miles long with a total fall of 1,720 feet. Based on maximum operating pool elevations of the six main stem dams in the reach about half of this head is still undeveloped -- a potential source of additional hydro-power. In addition, four

of the six main stem dams have a total of 15 flood control tunnels which could be modified to accommodate turbines. Although little additional energy would be obtained by this move, substantial increases in capacity could be developed.

Adjoining Pumped Storage Sites

157. Uplands adjacent to the existing main stem reservoirs provide nearly unlimited opportunities to develop head for pumped storage hydro-power. Representative head differentials available in the various reaches are tabulated below.

Project	Approximate Adjoining Head Left Bank (feet)	Right Bank (feet)
Fort Peck	700	950
Garrison	300	350
Oahe	200	250
Big Bend	400	350
Fort Randall	450	700
Gavins Point	250	250

Recreation, Fish and Wildlife

158. Resolutions by the Public Works Committee in 1966 and 1967 called for examination of the possibilities at Oahe and Fort Randall for providing subimpoundments primarily for recreation and fish and wildlife preservation. The origin of this interest was local concern that fluctuating lake levels and high waves would seriously limit use of the lakes for boating, water skiing and fishing. The other major concern was perpetuation of the northern pike as a trophy

fish in both lakes -- the fish that was, in those years, responsible for attracting a significant share of the lakes' visitors.

159. The northern pike did indeed provide a trophy fish in both Lake Oahe and Lake Francis Case. This species has all but disappeared from the lakes, due primarily to the almost total lack of acceptable spawning and nursery areas (water areas 3 or 4 feet deep, stable bottom supporting a good growth of rooted aquatic vegetation). Also, the food (forage fish) of the northern pike in the lakes is of limited quantity. To the extent they could circumvent these two problems, subimpoundments would improve conditions at the lakes.

160. Concern over detrimental impacts of the open lakes upon recreational boating have since proven to be largely unfounded. Fluctuations have not been as serious as suspected. An operational change in Lake Francis Case levels has helped at that project. Studies made in updating both projects' recreation master plan have not revealed any significant demand for subimpoundment recreation.

161. One problem which does affect the quality of reservoir recreation is sedimentation. Significant siltation has occurred in several boat basins and boat ramp locations at public use areas. Serious problems have been documented at 20 out of a total of 65 public use areas investigated.

162. As mentioned in paragraph 106, a reach in the upper end of the study area has been designated as a component of the National Wild and Scenic Rivers System. This reach, known as the Missouri Breaks was designated by PL 94-486. Another area with designation potential was identified in an unpublished report completed in 1971 by the Bureau of Outdoor Recreation, "Missouri River - Gavins Point Dam to Ponca State Park." Recreational values include the river's historical significance, the largely natural state of the channel

and the opportunities for boating and wildlife observation.

163. The 340,000 acres of project lands surrounding Fort Peck Lake are considered by the citizens of northeastern Montana as one of the regions outstanding recreation potentials, made even more attractive by the further adjacent Federal proposals (para. 105 and 106). A need recurrently mentioned is the addition of more all-weather roads to project lands where public use areas exist or are designated for future development.

164. Statewide Comprehensive Outdoor Recreation Plans for Montana, North Dakota, South Dakota and Nebraska attest to the proposition that public access to the open Missouri River reaches is desirable. This need is largely unmet as of today. This status of river access was verified in a letter from North Dakota Game and Fish Department, July 1972, commenting on the draft environmental impact statement covering the Missouri River bank stabilization work between Garrison dam and Lake Oahe authorized by PL 88-253 and PL 90-483. Mr. John Hjelle, Bismarck Tribune editor has also reported on the interest of Bismarck citizens in developing recreational opportunities on the Missouri River.

Improvements Desired

165. During the week of 28 June 1976 four public meetings were held across the study area. The following paragraphs recapitulate positions expressed during the meetings.

Bismarck, ND

166. 125 persons attended the meeting; 24 made statements.

- 13 persons identified bank erosion as a serious problem and called for stabilization installed and maintained at Federal expense
- 4 spokesmen for utilities and 1 for USBR indorsed additional hydro-power
- 5 persons were concerned over waterlogging or flooding
- 3 said fluctuating releases would make irrigation difficult
- 3 people wanted better recreation - primarily river access
- 1 objected to extending the navigation project above Sioux City
- U. S. Fish and Wildlife Service said changes in tailwater would detract from the fishery and that rising water table would necessitate relocating the Garrison fish hatchery.
- A consultant to Burleigh County, wanted the Corps to give the County written assurance that additional power would cause no waterlogging. He questioned Corps' ability to provide "soft" bank protection and particularly questioned the cost estimate. His preference was complete stabilization similar to the lower Missouri. To avoid another Niobrara, the Corps will have to canalize the river from 10 miles above Bismarck into Oahe Reservoir to nulify effects of the Oahe delta. The Corps has a duty to indorse emergency bank protection legislation now being drafted by North Dakota Congressional delegation.
- Director of Hydrology for North Dakota State Water Commission said aggradation below Bismarck (Oahe delta) has raised the water table. His interpretation of our plans was that we propose to buy Buford-Trenton, to which he objects. He wants the Corps to study or to fund North Dakota to study (1) the hydrologic budget; (2) a hydrologic model to predict system response; (3) predictions of future aggradation and (4) recommended methods to control aggradation.

Great Falls, Mont.

167. 40 attended the meeting; 17 presented statements.

- 12 utilities and USBR advocated more power
- 1 opposed extension of the navigation project
- Department of Natural Resources and Conservation (Montana) found the plan to install only one unit and observe its environmental effects unacceptable. They felt either one or two units without reregulation will increase erosion and bother irrigators. They asked further study of reregulation.
- Montana Department of Fish and Game, assumed increases in power plant discharge would result in increased velocity and erosion. The Corps plan has provided no hydrology on flow regimen, no transmission plans, no specific locations of future erosion and no mitigation proposals. The Department is opposed to plans to observe effects of one unit.
- U. S. Fish and Wildlife opposed either one or two units without reregulation. Preference among the conditions given them for evaluation is two units with a reregulation dam at river mile 1766.23 with adjacent lands managed for habitat. However, they thought there was merit to a plan consisting of one unit with reregulation.

Pierre, SD

168. 75 attended the meeting; 18 presented statements.

- 3 utilities and USBR indorsed power
- The Mayor of Gregory and two others emphasized the need to add water supply and irrigation to the Gregory pumped storage project.
- 6 people spoke to non-Corps concerns such as the Oahe diversion project, pipelines to Wyoming, private irrigation problems.
- Secretary of the Department of Natural Resource Development South Dakota said his board indorsed power at Fort Randall and Gregory County with priority to the latter, and with municipal and irrigation supply added.
- Administrative Assistant to Senator Abourezk said the Senator likes the erosion control and recreation river proposals. Hydropower is complex and controversial; additions must not damage the

Karl Mundt Wildlife Refuge. Pumped storage at Gregory County should have first priority. Although the Corps is not able to resolve water use issues among Federal and State interests in this study, such resolution must be reached soon.

● U. S. Fish and Wildlife expressed concern that additional units at Fort Randall will destroy the fishery. If that is so, they oppose the units. Bank stabilization must restore the natural character of the river, not canalize it as was done below Sioux City. Fish and Wildlife supports the recreation river concept. The Corps made a mistake in dropping all pumped storage except Gregory County.

● South Dakota Department of Environmental Protection said Corps information is very limited. The study has no water quality information. DEP takes issue with the statement that no serious erosion exists between Oahe and Fort Randall, and that no adverse effects will stem from pumped storage. The Corps should remedy the problem above the Niobrara. DEP wishes to be assured that NEPA was used as a decision making tool.

● South Dakota Game Fish and Parks said hydro-power at Fort Randall would be disastrous to the downstream fishery because of excessive fluctuations in stage and velocity. It would flood more lands and degrade the Karl Mundt refuge. Gregory County was dealt with lightly by the Corps; pumped storage should be thoroughly evaluated. The bank stabilization concept was applauded, but it should await completion and evaluation of Sec. 32. GF&P tentatively agreed to the recreation river concept.

Yankton, SD

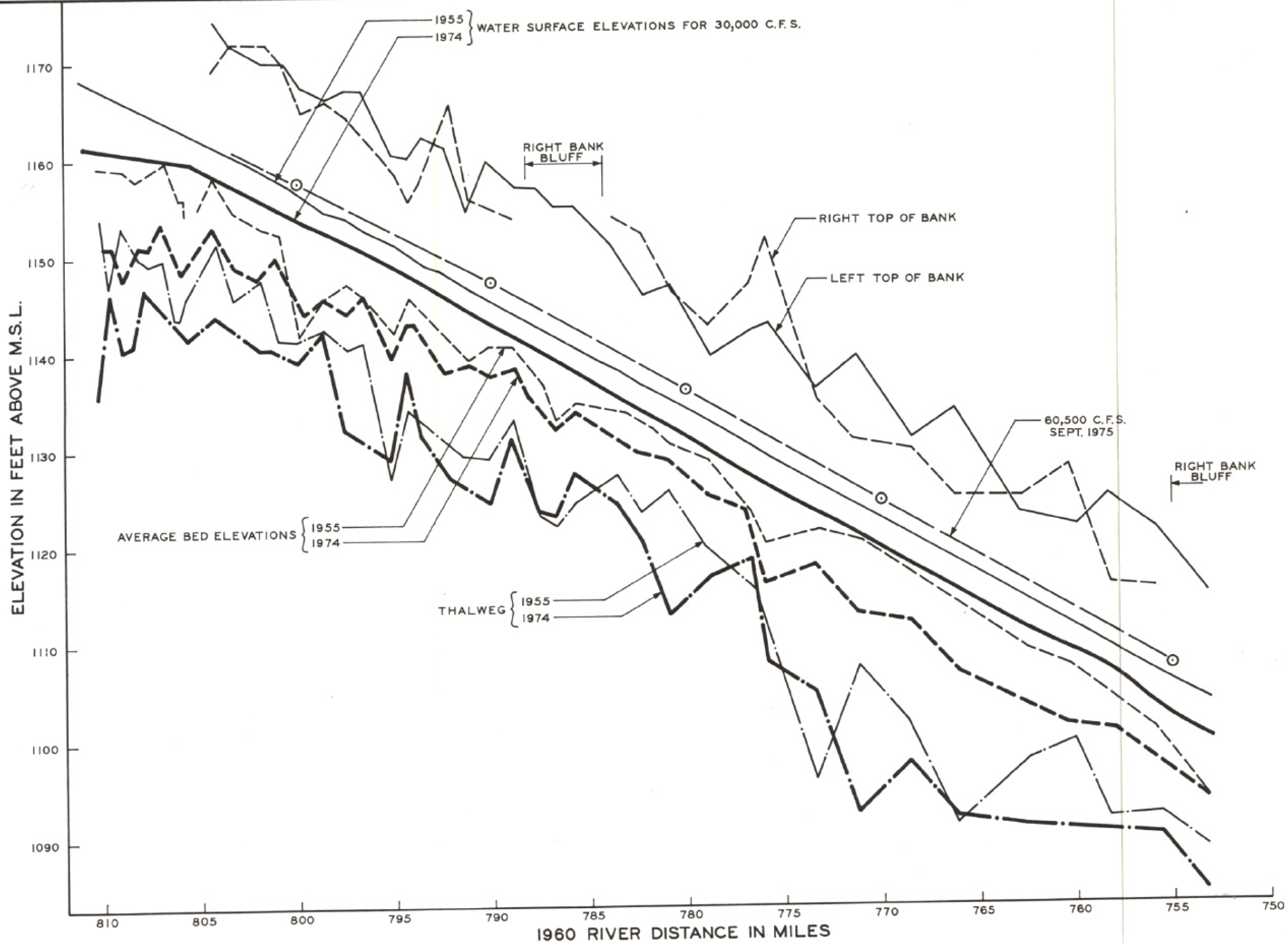
169. 155 attended the meeting; 22 spoke.

● 3 utilities, 2 communities, and USBR advocated additional power.

● South Dakota Environmental Coalition, Minnihaha Sportsmen and Conservation Club, Northeast Nebraska Wildlife Federation, Nebraska Chapter of the Wildlife Society and Dakota Environmental

Council indorsed the Recreation River plan.

- Six others advocated bank stabilization
- Two investor-owned utilities objected to the preference clause
- Iowa Public Service said scouring of the bed at Sioux City results from Corps' reservoir operation and should be addressed. Reduced winter releases are a second problem. The Corps is proposing to generate in an area of power surpluses.
- Nebraska Public Power District said the Corps ought to give consideration to letting others use the Missouri River lakes for pumped storage operation.
- Mayor of Springfield was disappointed that locals did not have a major role in conducting the study. He asked the Corps to do something about the delta and swamping near Springfield.
- Sioux Falls asked that water quality be preserved for municipal use.



MISSOURI RIVER

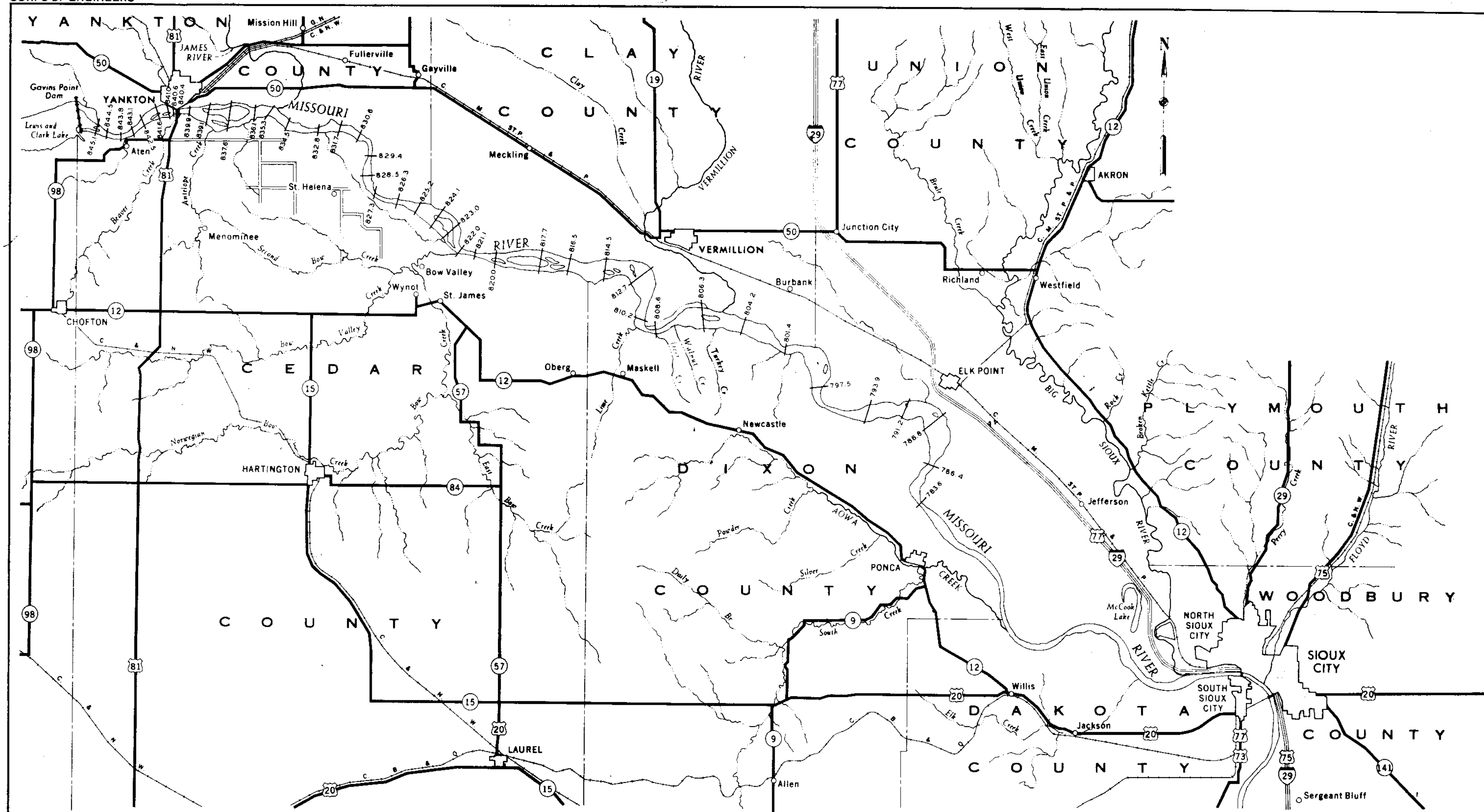
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

PROFILES

GAVINS POINT DAM TO PONCA, NEBRASKA

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977



MISSOURI RIVER

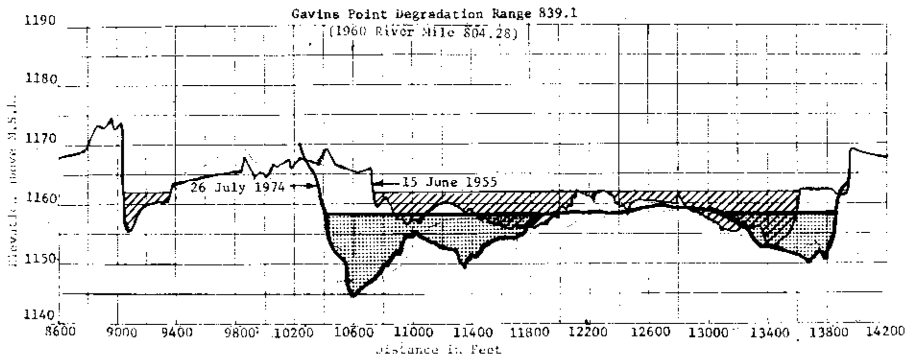
SOUTH DAKOTA, NEBRASKA, SOUTH DAKOTA, MONTANA

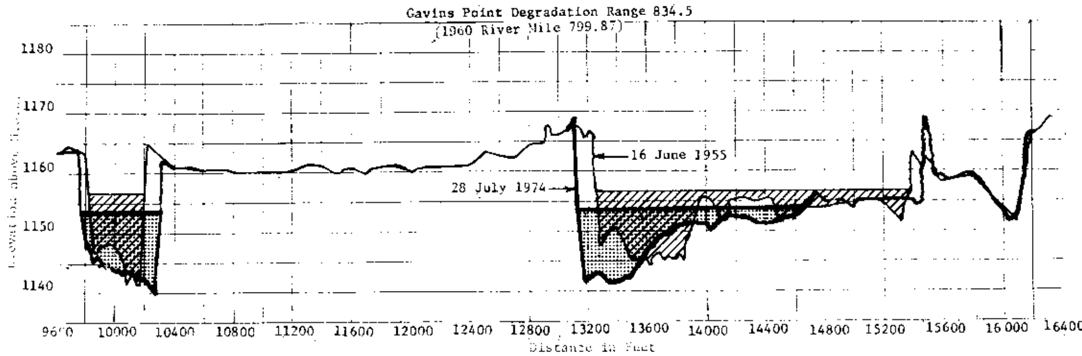
INDEX TO CHANNEL CROSS SECTIONS

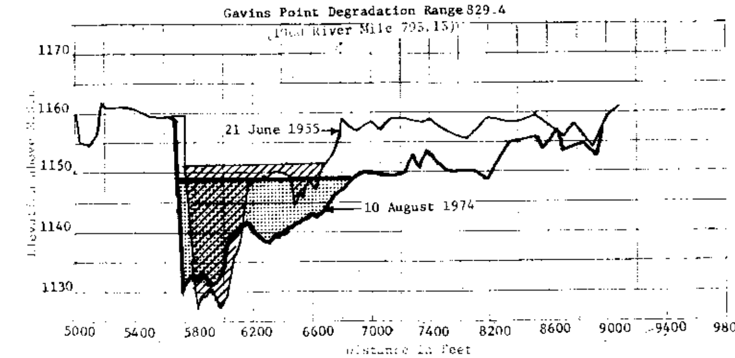
GAVINS POINT DAM TO PONCA, NEBRASKA

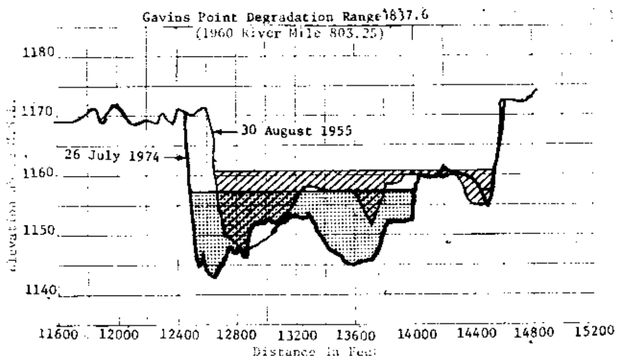
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

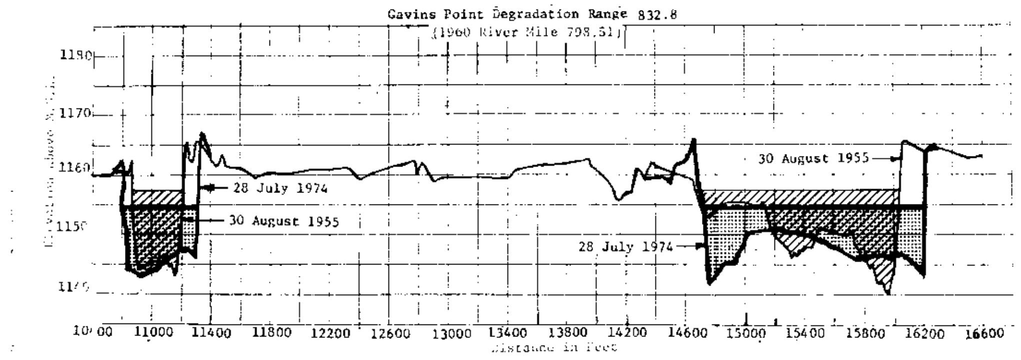
FEBRUARY 1977

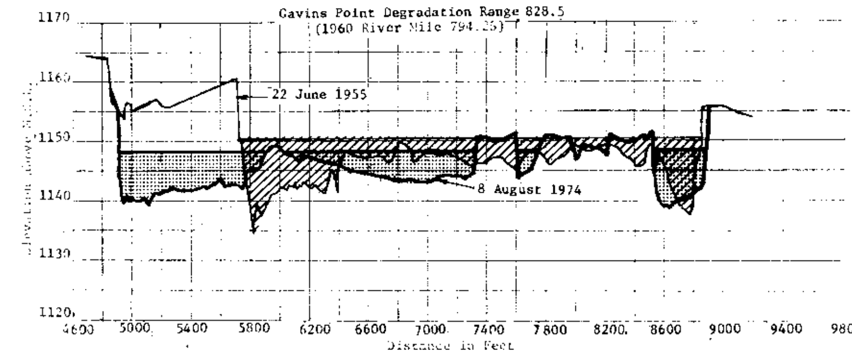


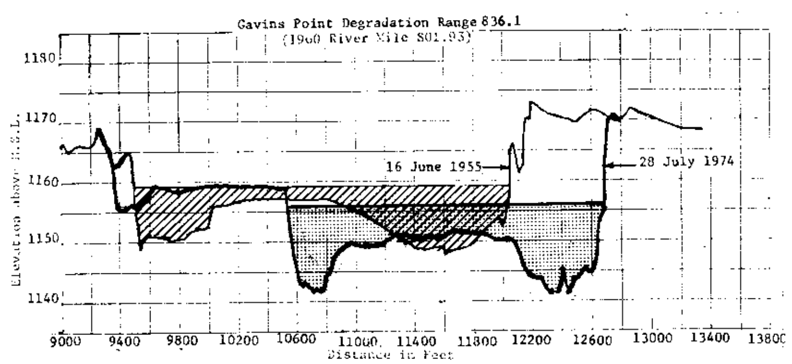


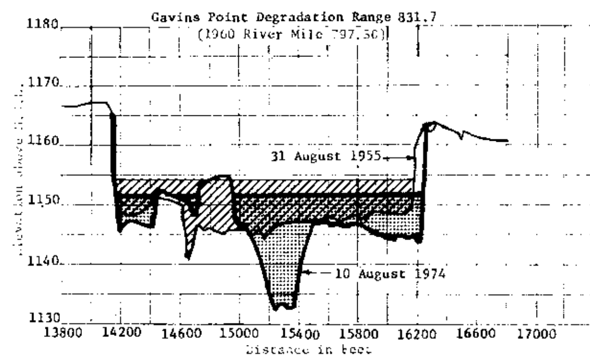


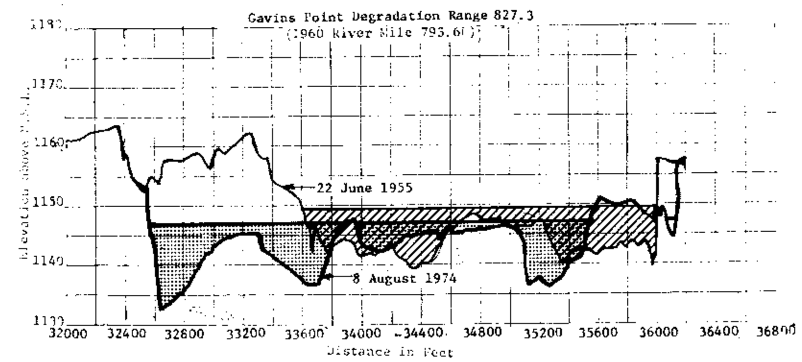


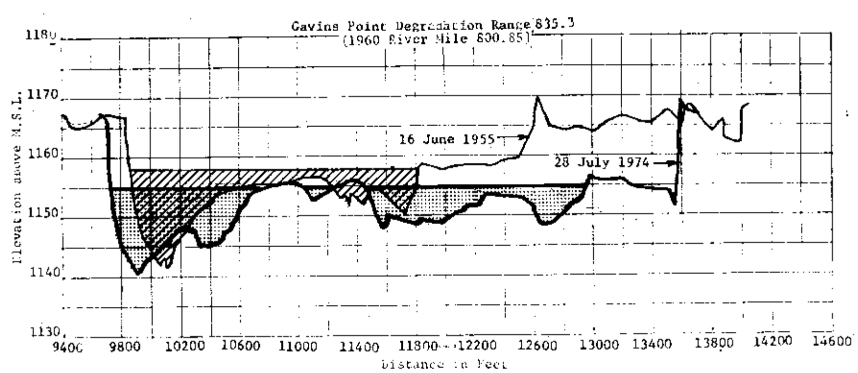


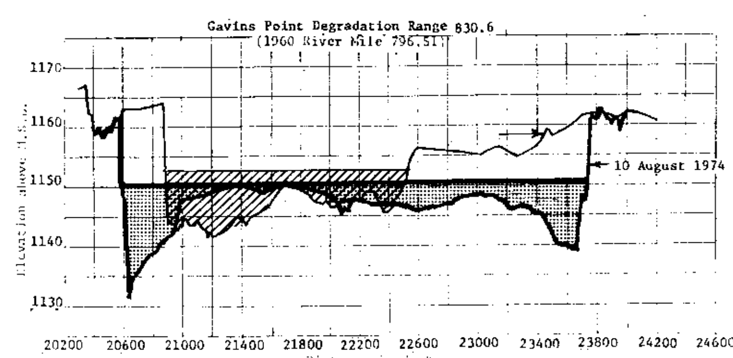












MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, SOUTH DAKOTA, MONTANA

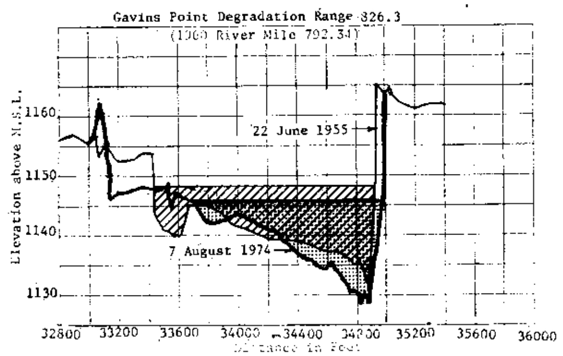
CROSS SECTIONS

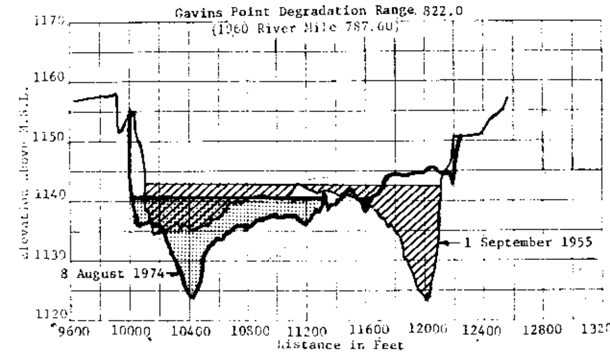
GAVINS POINT DAM TO PONCA, NEBRASKA

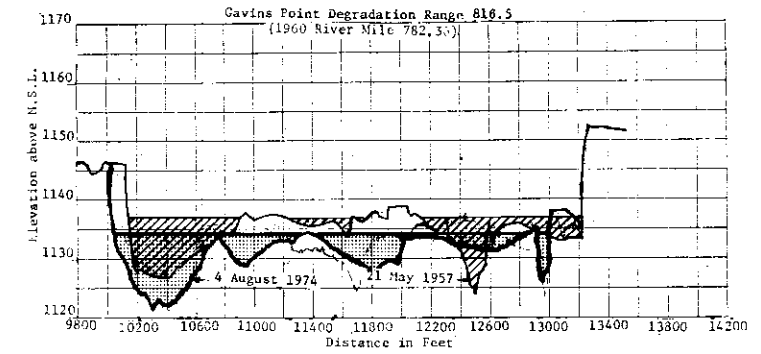
RIVER MILE 827.3–839.1

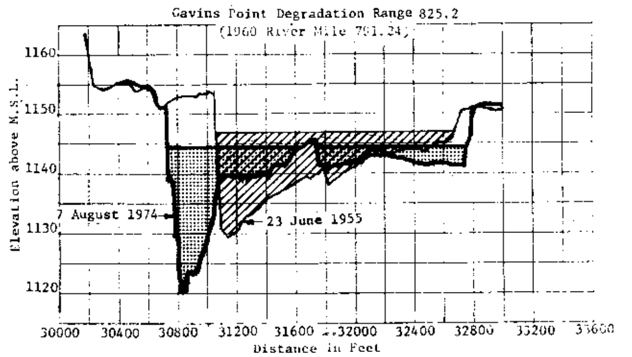
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

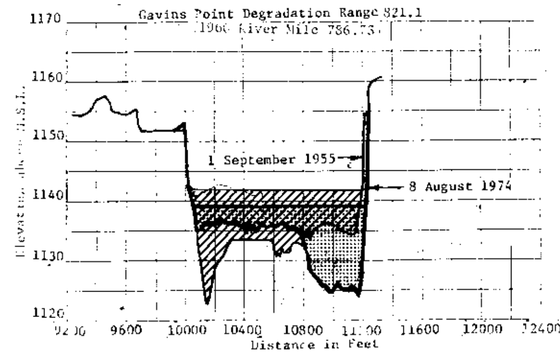
FEBRUARY 1977

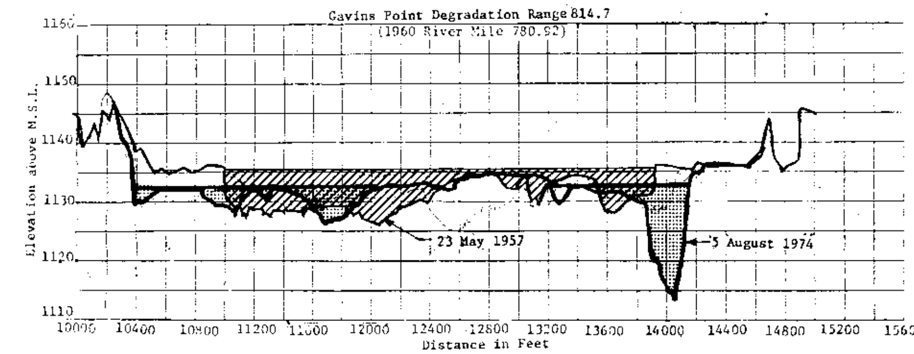


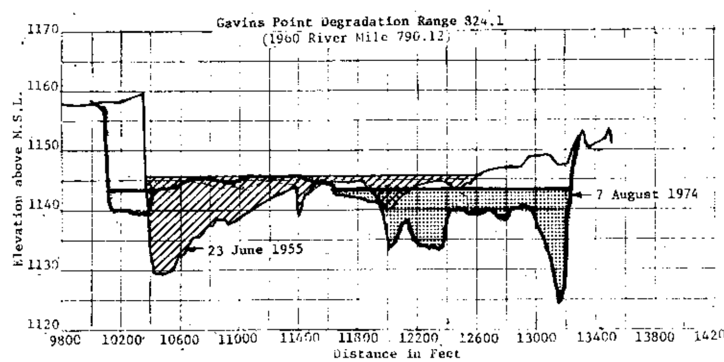


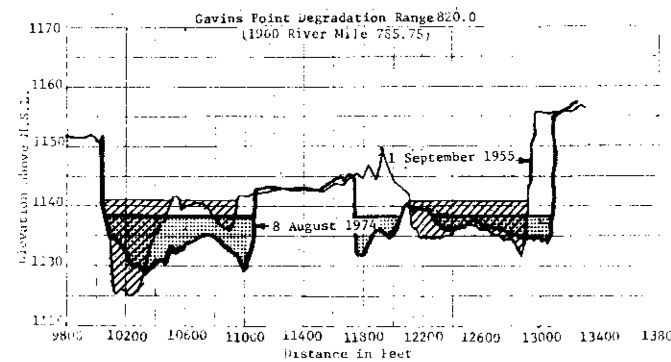


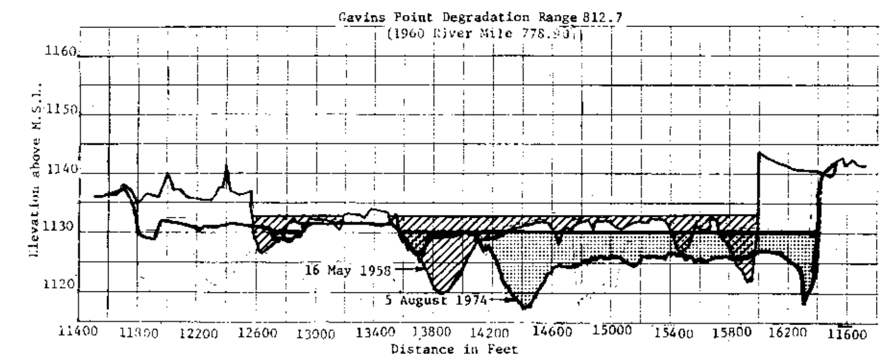


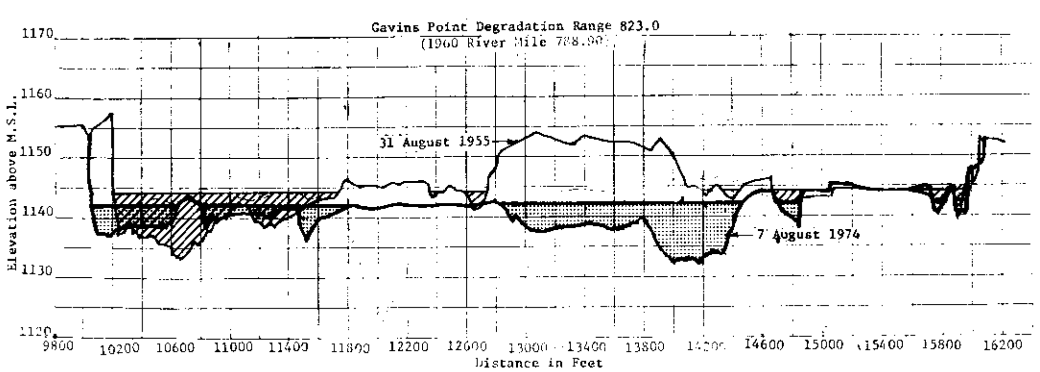


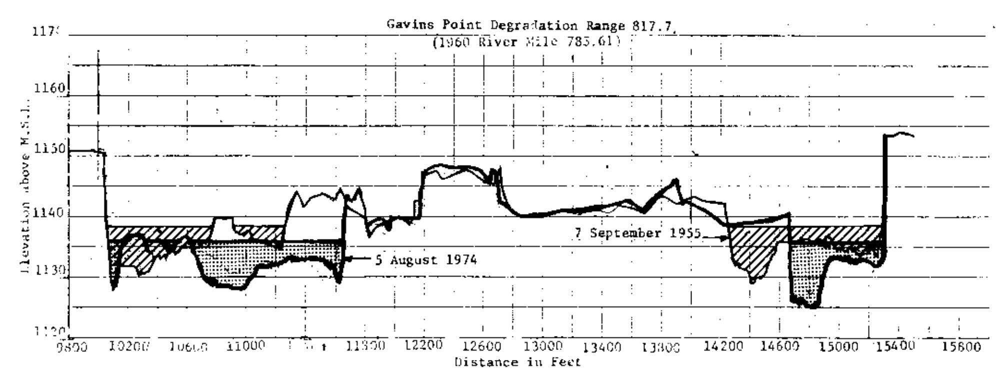












MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, SOUTH DAKOTA, MONTANA

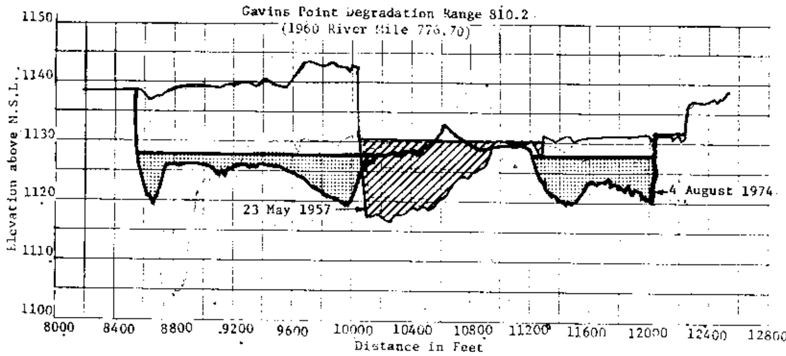
CROSS SECTIONS

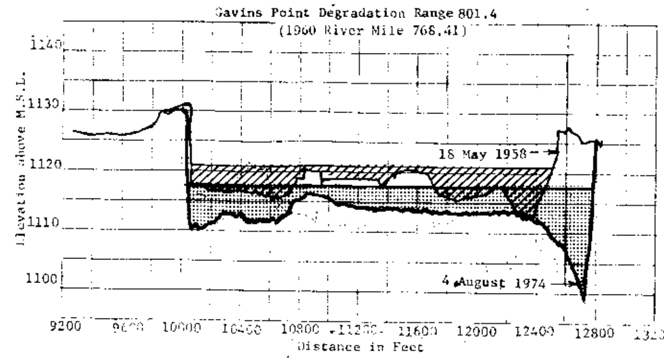
GAVINS POINT DAM TO PONCA, NEBRASKA

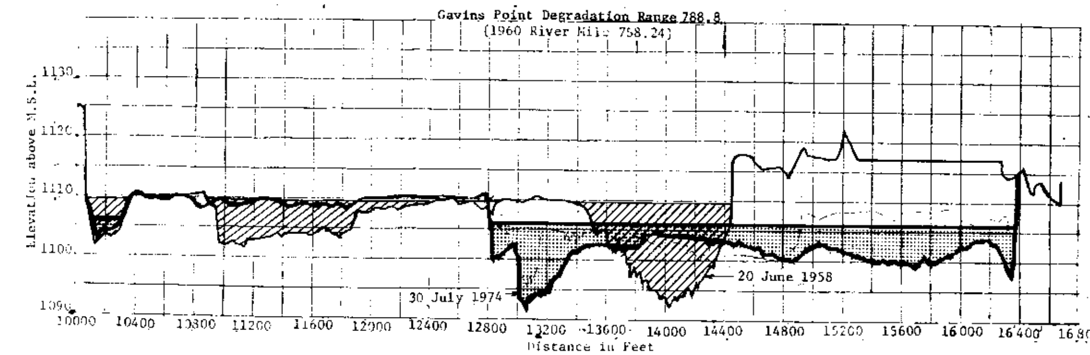
RIVER MILE 812.7–826.3

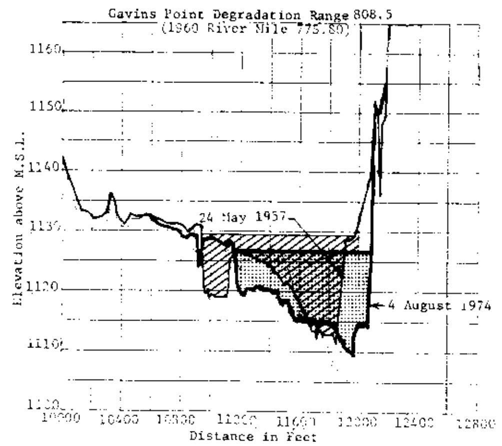
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

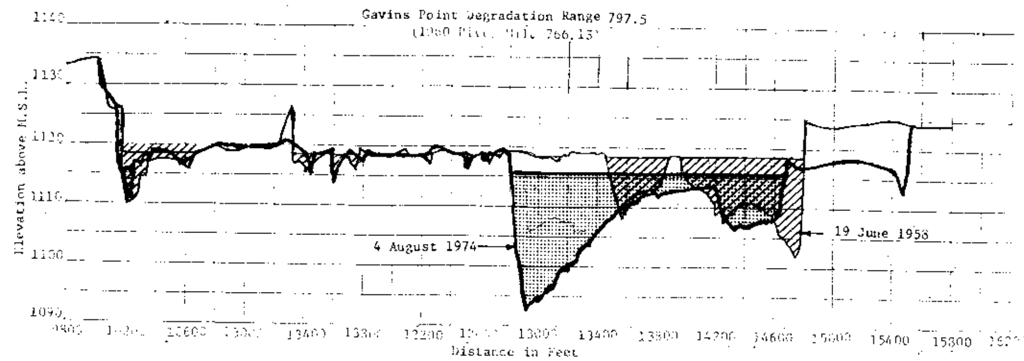
FEBRUARY 1977

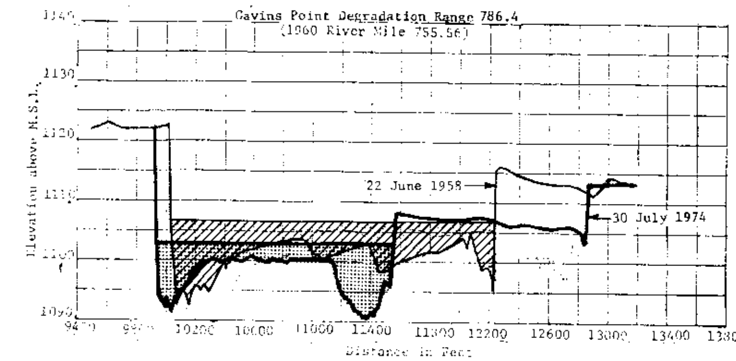


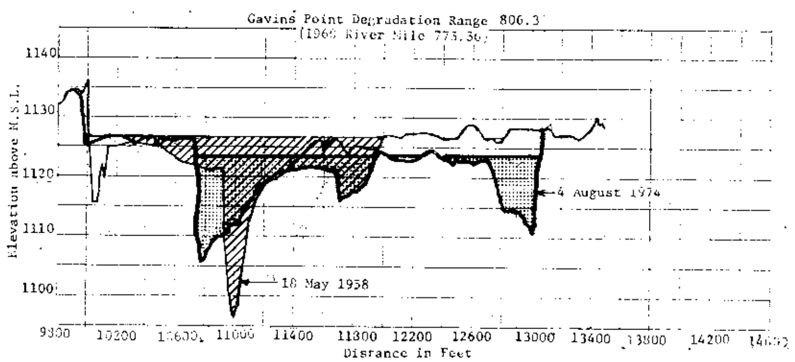


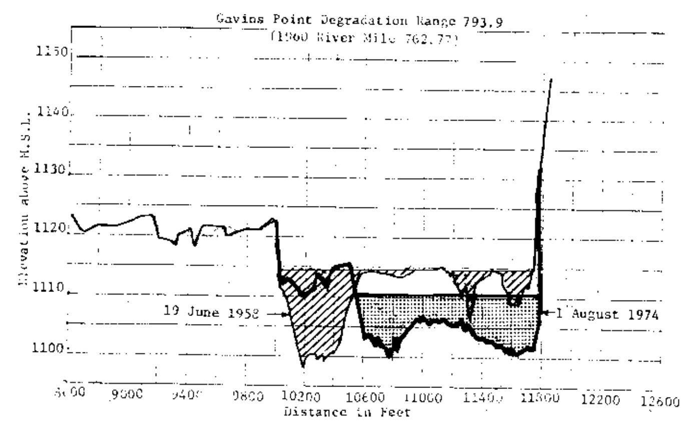


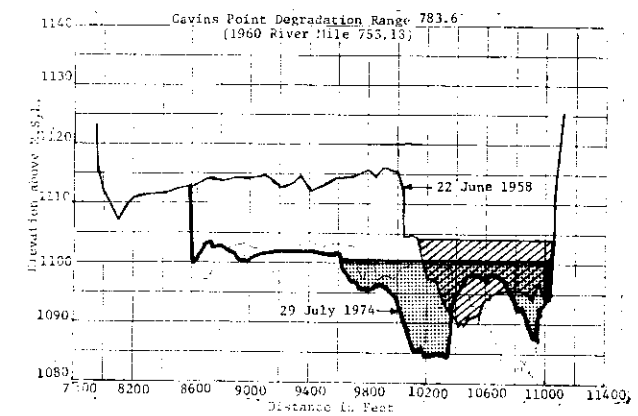


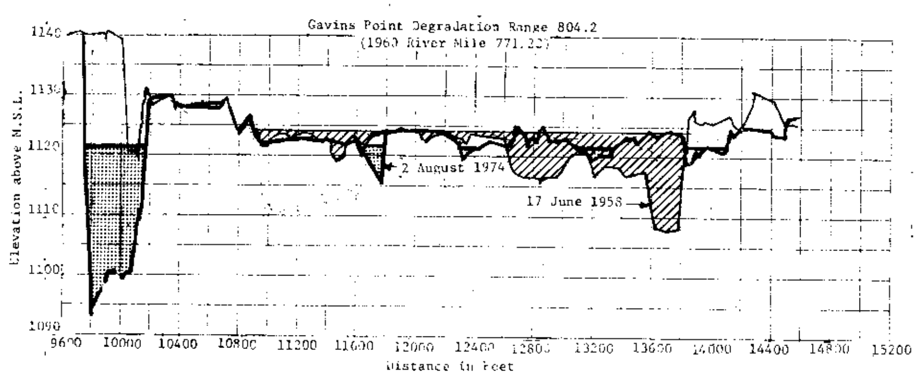


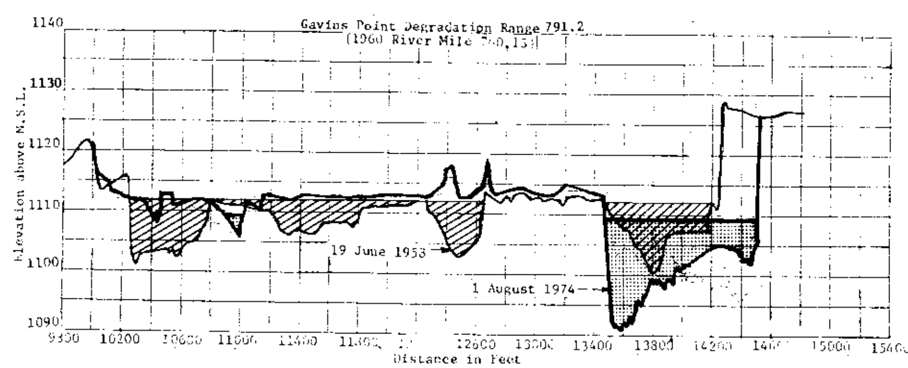












MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, SOUTH DAKOTA, MONTANA

CROSS SECTIONS

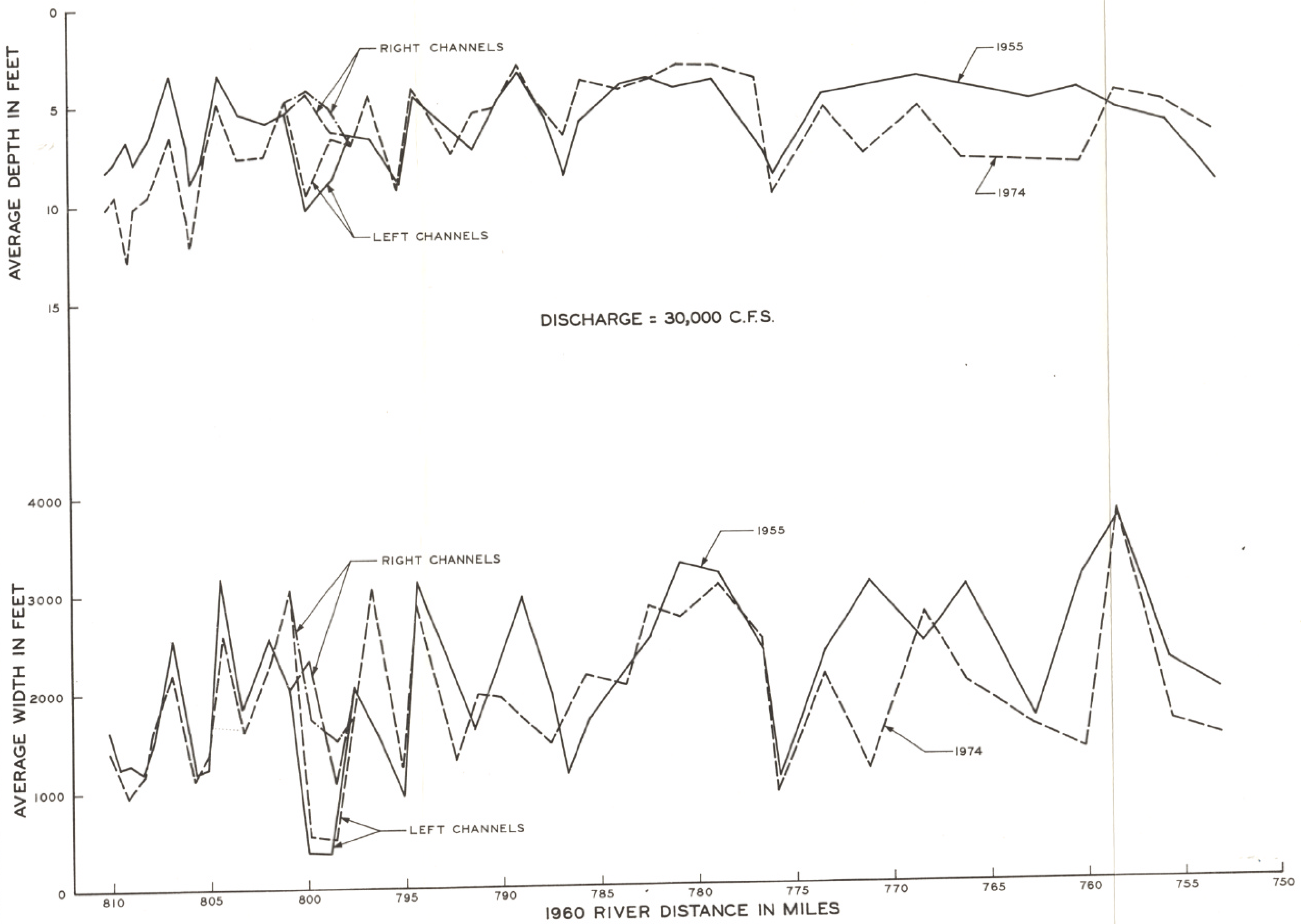
GAVINS POINT DAM TO PONCA, NEBRASKA

RIVER MILE 783.6 - 810.2

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977

APPENDIX I
PLATE C-5



MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

AVERAGE RIVER DEPTH AND WIDTH
GAVINS POINT DAM TO PONCA, NEBRASKA

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE C-6

SECTION D

FORMULATING A PLAN

FORMULATING A PLAN

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SECTION D

FORMULATING A PLAN

1. Establishment of Principles and Standards for Planning Water and Related Land Resources by the Water Resources Council in 1973 has produced a rather explicit set of concepts and objectives applicable to plan formulation. Almost every Federal agency dealing with water resources has indorsed these concepts by issuing expository rules of its own; the Corps of Engineers is no exception. There is, consequently, a voluminous and widely available literature documenting the objectives of national economic development and environmental quality, and the processes to be observed in seeking their attainment. A detailed recitation of these procedures here is not necessary; by Executive Order, compliance from Federal agencies is required "as appropriate." 1/

2. Application of P&S concepts, to be fully appropriate, requires the ability to seek without undue constraint the path of economic efficiency, the path of environmental quality, and the best melding of the two. This complex procedure would be simplified if plans could be formulated by drafting every element on a clean page - with no past-due obligations cluttering the ledger sheets. Not every element of this study can be so treated. The main stem system predates by several decades the Principles and Standards; concepts which prevailed during its formulation have faced the test of

1/ Line 3, Standards for Planning Water and Related Land Resources operation. Some residual opportunities have been identified; some residual problems have surfaced. The next two paragraphs discuss how this background can result in formulation procedures somewhat different than application of the Principles and Standards would lead to in an unconstrained setting.

3. Sections 122 and 216 of the 1970 Flood Control Act affirm Congressional understanding that in the wake of project completion there may still be problems and that remedies to such problems should be considered. At times, however, the link between good will and good deeds is frail indeed. Thus, the Principles and Standards, starting with a clean sheet, would formulate any action, including those to rectify residual problems, only to the extent it contributed to two national objectives, economic development or environmental quality. State officials have repeatedly challenged this concept as it applies to bank stabilization. They point out that benefits of the main stem system are widespread; that the reaches of open river serve as indispensable operational conduits which make possible the realization of all system benefits - whether flood control, power generation, navigation, irrigation or water supply. These officials are quick to add that little consideration has so far been given to preserving the well-being of the conduits themselves. This approach has not been without persuasion in the view of Congress; to the extent it has acted, a formulation procedure differing from the Principles and Standards has been invoked.

4. The EQ objective also feels the constraints imposed by studying a system in being. Initial and irreversible actions have been made long since; today economic, social, political, and environmental factors incline the scale toward continuation of present outputs or toward still more man-made changes. In reality, then, the option to undo the project as a whole is no option at all. This, in turn, tends to establish the frustrated conclusion that no feasible change in present conditions would contribute to the EQ account, that EQ planning in short is a recitation of the "do-nothing" alternative. The fact is, however, that elements of the system have in recent

times been reviewed with a critical eye and some have been challenged in the courts. The door is open; EQ concerns can be evaluated and EQ elements can be formulated recognizing both the hazards and the opportunities of trying to do something rather than nothing.

Factors Affecting Formulation and Evaluation

5. Certain factors play a major role in plan formulation since they shape decisions affecting the scope, feasibility and impact of non-structural measures and alternative structural plans. Technical, economic, and environmental and other factors, which played a decisive role from the initial screening of alternatives through the final iteration of selecting a plan, are identified in the following paragraphs.

Technical Factors

6. Significant technical criteria were specific to the several functions investigated, and are listed by category in this sub-section.

FLOOD CONTROL

7. Missouri River channel capacity above the mouth of the Niobrara River has declined from a pre-project level of 120,000 cfs to a present day 40,000 cfs.

NAVIGATION

8. For screening purposes a tow configuration four barges long

by three barges wide, transporting 18,000 tons was assumed capable of operating all reaches to be navigated.

9. Locking time for such a tow was assumed to be 40 minutes, lock utilization was assumed to be 100 percent.

10. Ice free navigation was assumed to have the same duration upstream of Sioux City as it has downstream, a nominal eight months.

BANK EROSION

11. After an initial "one time" slump, experience indicates that high banks incur no increase in erosion as a result of fluctuations in river stage, nor do these fluctuations have an appreciable effect on sediment transport, bar configuration or channel shifting.

12. Operation of the main stem system has essentially eliminated sediment-laden overbank flows. With the counterbalancing accretion process thus halted, high bank erosion results in a permanent and irreversible loss of high valley lands and high bank islands.

13. The critical element in designing Missouri River bank stabilization works is not protection against high flow velocities, but against undercutting as a result of bed scour.

HYDRO-POWER

14. Critical head (gross) for existing units was used to match turbine and generator sizes on new units.

15. Critical head (gross) for pumped storage was taken as the difference between minimum usable forebay elevation and afterbay base of exclusive flood control.

16. Sizing of pumped storage projects was determined by available off-peak pumping energy.

17. Maximum turbine size was set by a maximum penstock velocity of 35 fps, above which adequate design data were lacking.

18. Discharge from enlarged power plants was designed to remain in bank with very few exceptions; for these, remedial actions are anticipated.

19. Enlargement of hydro-power plants will increase hourly variations in discharge. Peak rates will be higher but of shorter duration; off-peak rates will be lower or will last longer or both. At those plants without a reregulation structure fluctuations will attenuate as they travel downstream, virtually disappearing within 50 miles. At those plants with reregulation structures, fluctuations downstream will be less than they are today.

20. System releases are regulated to meet objectives of flood control, navigation, water supply and quality, and balance between summer and winter rates. Daily and weekly average discharge rates from the two lowermost reservoirs respond to these requirements and not to hydro-power needs. Power addition would not affect system releases.

21. Changing seasonal load requirements are increasing the need for July and August generation and reducing the winter demand. The four upstream projects have the capability to modify future operating patterns in response to that need. Added generating capacity at Fort Peck and Garrison would augment that capability.

Economic Criteria

22. Although economic criteria have more general applicability than do the function-oriented technical criteria, some differences among functions are evident in the following paragraphs.

BANK EROSION

23. Measures to ameliorate bank erosion problems have been portrayed to Congress by affected interests within this study area as a "cost of doing business" on the main stem system which should be accomplished by the Federal Government.

24. Since legislative action over the past 13 years has been in accordance with this viewpoint, consideration should be given to developing such remedial measures so that they are as cost effective and economical as possible.

25. Cost estimates are based on 1976 dollars; they include construction, lands, easements and rights-of-way. Annual costs are based on a project life of fifty years and reflect Federal and non-Federal average annual equivalent values and a 6-3/8 percent interest rate.

OTHER STRUCTURAL MEASURES

26. Tangible benefits exceed project economic costs.

27. A fully implementable NED plan is designated which maximizes net economic benefits. Net economic benefits are maximized when scale is optimized and a plan is efficient. The scale of the NED is determined such that benefits of the last increment of output for each measure, purpose, or separable segment in the plan at least equals the economic costs of that increment. In meeting a given objective, a plan is efficient when the output of the plan is achieved in a least cost manner.

28. Power benefits are based on the provision of like energy and capacity by the least costly power alternative, which for this study area is combustion turbine.

29. Navigation benefits are based on the provision of transport by the least costly alternative, which for this study area is unit train.

30. Resource demand exceeds project output.

31. All benefits and costs are expressed in comparable terms to the fullest extent possible. The annual charges include interest; amortization; and operation, maintenance, and replacement costs. Annual costs are based on a 100-year amortization period (50 years for navigation and pumped storage), 6-3/8 percent interest rate and July 1976 price levels, at least for selection of final plan elements.

32. Although formulated with a 100-year life, hydro-power elements must be able to repay allocated costs in 50 years.

Environmental and Other Criteria

33. An interdisciplinary approach was used to insure integration of the natural, social and physical sciences and environmental design arts in the planning process.

34. Requisite ecological data were gathered and utilized in formulating the resource-oriented plan elements.

35. Fish and Wildlife Service "habitat unit" evaluation criteria were used to identify habitat type and value for baseline conditions upon which to predict project-induced changes in the study area's biological community.

36. Significant detrimental environmental effects were avoided where possible; feasible mitigative measures were formulated to minimize such effects when they were unavoidable.

37. Recreational activity demand generally was predicted from current Statewide Comprehensive Outdoor Recreation Plans; monetary worth of visitations was based on Principle and Standards criteria.

38. Criteria found in Public Law 90-542 as amended, and the

Evaluation Guidelines approved by the Secretaries of Interior and Agriculture in February 1970 were used in analyzing recreation river potential.

39. Predicted effects of fluctuating river stages and velocities on fish and fish habitat were based, in part, on procedures, information and criteria presented in "The Determination, Assessment and Design of 'In-Stream Value' Studies for the Northern Great Plains Region," 1975, prepared by Ken D. Bovee, University of Montana.

40. The size and number of subimpoundments for propagation of northern pike were based on fingerling stocking rates of 30,000 per surface acres of littoral zone and fry stocking rates of 100,000 per surface acre of subimpoundment.

Possible Solutions

41. A study with objectives as numerous and broad as this one can be expected to generate a sizable number of possible solutions. The process of reducing this number to a final selected plan has observed one primary rule -- not to plow the same ground twice. If one criterion demonstrated the complete infeasibility of some study element, no search was made for more reasons to reject it. Additionally, an effort was made to evaluate first those criteria which could be obtained most easily and cheaply. Usually these turned out to be project costs and project benefits.

42. Adoption of this procedure did not stem from inability or unwillingness to assess environmental concerns. In fact, this screening technique was employed only when the structural measure was purposeless in the absence of an NED contribution; in most instances the EQ account, if evaluated in detail, would only have shown further detrimental effects. For example, if conversion of the James River to a barge canal shows economic return of ten cents on the dollar, there seems little point in a search for associated environmental costs. Similarly, if technical studies show that moving electrical energy in and out of a remote pumped storage site is infeasible by a wide margin, no amount of environmental analysis can result in project justification.

43. Quite a different approach was followed where possible structural solutions proved to be economically feasible. When it became necessary to evaluate project acceptability as measured by environmental impacts, substantial amounts of time and effort were invested. Every attempt was made to go deeper than a selection of adjectives intended to convey subjective conclusions. Engineering analyses and field observations were directed toward quantifying specific impacts in terms of acres, feet, feet per second, and the significance of these parameters to the existing environmental setting.

Flood Control

44. Flood control measures considered during the preparation of this report were:

- Flood control storage in new reservoirs upstream of Fort Peck or between Fort Peck and Garrison.
- Modification of operating criteria at existing projects.
- Modification of project boundaries.

45. Additional main stem storage would provide negligible benefits as a result of direct flow regulation. There are almost no

concentrated values subject to flooding in the study reach upstream of Fort Peck, and except for possible ice jam floods, the reach between Fort Peck and the mouth of the Yellowstone receives protection in excess of 100 years from Fort Peck regulation. Replacement flood control storage at these sites would be possible; under this concept flood storage would be transferred upstream from an existing project (Oahe for example) enabling the downstream site to maintain a higher level of storage and consequently of power generation. Studies showed this operation could increase by one percent the average annual benefits at Fort Benton or High Cow Creek. These projects, as documented in a subsequent discussion of hydro-power, show benefit-cost ratios lower than 0.5 to 1; a reservoir between Fort Peck and Garrison makes an even poorer showing. Additional storage for flood control was eliminated from further consideration.

46. Flood control storage could be increased by lowering the level of multi-purpose storage in the existing reservoirs. Studies made by MRD's Reservoir Control Center following the 1975 flood indicate this would be an unwarranted departure from sound operating procedures. Utilization of floodwaters for municipal and industrial use, as suggested in the 1958 Flood Control Act, is already being accommodated by the multi-purpose operation of the system to the fullest extent compatible with sound operation.

47. All studies conducted by the Corps subsequent to the 1975 flood indicate that the authorized functions of the multiple-purpose main stem reservoir system will be best served by a continuation without major modifications of the criteria in force at that time. This subject has been discussed with representatives of all Federal agencies concerned with water resource development in the Missouri

Basin as well as with responsible representatives of each of the Missouri Basin States. All indorse continued balanced, multiple-purpose operation of the main stem reservoir system and support continuance of the reservoir regulation criteria utilized to control the 1975 flood inflows. Modification of operating criteria was eliminated from further consideration.

48. Modification of project boundaries was an alternative retained for further consideration.

Navigation

49. In response to numerous Congressional directives to study an extension of the Missouri River navigation project from its present head at Sioux City, examinations were made of two possible routes and four possible terminals.

- Missouri River route; extend to Yankton
- Missouri River route; extend to Chamberlain
- Missouri River route; extend to Yellowstone River
- Missouri River route; extend to Fort Benton
- James River route; extend to Yellowstone River
- James River route; extend to Fort Benton

Each of these possible alternatives required further study.

Waterlogging

50. Possible solutions at the three locations within the study area identified as having waterlogging problems varied somewhat depending upon the proximate source of the water. Some solutions were applicable at every location; some at one place only. First determination of alternatives did not consider the question of Federal obligation to provide a solution; this was deferred to the second phase of analysis.

- Modification of operating criteria at existing projects
- Decrease in Missouri River stages by means of dredging
- Construction of levees

- Modification of interior drainage
- Transfer of interest in lands by fee acquisition or easement
- Flood plain management

51. Modification of operating criteria with the objective of reducing waterlogging would entail either a reduction in reservoir levels or a reduction in reservoir releases. The former would have a prohibitively costly effect on hydro-power generation and the availability of assured water supply for other multi-purpose functions such as irrigation, navigation and recreation. The latter would be completely incompatible with a reasoned accomplishment of the flood control function. This option was eliminated since the benefits gained would be far overshadowed by the benefits foregone.

52. Main stem channel dredging sufficient to eliminate problems arising from high water tables has been estimated to exceed <u>every year</u> the total purchase price of affected lands. This alternative was eliminated from further consideration.

53. Initial cost of protective levees approximates the market value of the affected lands, moreover levees reduce only the threat to surface flooding when constructed alone. To provide an effective remedy to waterlogging, well-point dewatering is a necessary adjunct. The combined economic costs are markedly unfavorable. The levee-pumping alternative was eliminated from further consideration. A combination of levee and tile field was likewise rejected as lacking economic feasibility; moreover it would not accomplish its intended purpose of lowering the water-table during flows of quite frequent occurrence.

54. Modification of interior drainage by such measures as increasing gradient toward the river, installation of stoplog structures and pumping interior runoff over such structures during periods of high Missouri stage, showed promise at Buford-Trenton and was

retained for further study.

55. Acquisition of an interest in the waterlogged lands appeared to be a workable solution at all three locations: Buford-Trenton, the reach downstream of Bismarck, and below Fort Randall.

56. Flood plain management and land use planning to preclude inappropriate development of lands with a high water table showed promise in the Bismarck area and were retained for further study.

Bank Stabilization

57. Three alternatives were identified which would be responsive to the public demand for amelioration of economic losses stemming from bank erosion. A fourth procedure is mentioned because of its considerable public support and not its efficacy.

- Extension of the so-called "hard" protection which is now installed from Sioux City to the mouth, and is aimed at controlling, and usually **constricting**, the river.
- Construction of "soft" protection which allows the river to retain the area between the present high banks, but attempts to halt further loss of high valley land.
- Federal purchase of a buffer strip on both sides of the river.
- Elimination of power peaking operations.

58. Excepting along those river reaches where it serves the additional function of training a navigation channel, hard protection has little basis for selection. Although it minimizes loss of arable land, it has been widely criticized as being destructive of habitat and is far more costly than soft protection. It was not considered further.

59. The concept of soft protection received widespread indorsement during the course of this study and was retained for further

consideration.

60. Consideration was given to Federal purchase of a buffer strip on each side of the river, but because of uncertainties as to where erosion might attack, many thousands of acres would have to be acquired. For purposes of evaluation a buffer strip one-quarter mile deep was assumed, although this would undoubtedly prove insufficient in some places. This option was dropped because it does not solve the basic problem of continuing loss of irreplaceable land resources and lacks any appreciable public acceptability.

61. On several past occasions State officials have proposed to reduce the economic impacts of bank erosion by eliminating hydro-power peaking operations and the associated fluctuations in streamflow. This alternative would undoubtedly fail the test of time, since it would not significantly reduce erosion losses and would provide no accretion gains; nonetheless, affected citizens may attempt its enforcement as a last resort if no workable solution is proposed. This approach would seriously diminish the power peaking capability of the main stem reservoirs. It would rule out consideration of additional generators and would cut output of the existing power plants during critical periods of peak demand. At Garrison, for example, the reduction in capacity could run as high as 50 percent; the replacement cost of these kilowatts would exceed six million dollars per year. This is not a logical selection.

Hydro-Power

62. The authorities under which additional capacity for generating electricity was examined in this study were all linked to the Missouri River. Hydro-power is not, of course, the only means by which more electrical energy can be provided in the area; indeed the very provision of more electrical energy is viewed by some as a detriment to quality of life. A number of possible alternatives thus required screening some of which lay outside the authorities of the Corps.

- New dam construction upstream from Fort Peck
- New dam construction between Fort Peck and Garrison
- Tailwater lowering at existing dams
- Additional units at existing projects
- Pumped storage projects
- Load management
- Economic incentives
- Thermal generation

NEW DAM CONSTRUCTION

63. In June 1963, a joint Interior-Corps report was prepared for the upper Missouri River basin which discussed eleven structural plans for additional hydro-power. The best plan involved a dam two miles upstream from Fort Benton, and a High Cow Creek Dam, 23 miles upstream from the Montana State Highway 19 bridge. The report was submitted to Federal agencies and the Governor of Montana for review in 1964. The plan was not supported by the State of Montana and no action was taken on the report. A review of the projects was made under this study and a tabulation of the updated power data follows:

	Rated Capacity (MW)	Dependable Capacity (MW)	Annual Energy (MWH)	1975 First Cost (Million$)	Capital Cost Per Kilowatt	Benefit Cost Ratio
High Cow Creek	720	781	1,555,000	671.1	932	0.5
Fort Benton	300	331	710,000	339.6	1132	0.4

No addition of further functions such as flood control brought either project close to economic feasibility.

64. Four potential damsites on the Missouri River between Fort Peck Dam and Garrison Reservoir (Lake Sakakawea) were considered

for power production and other purposes by the Bureau of Reclamation in a 1969 report. In downstream order, these sites were Little Porcupine, Wolf Point, Brockton, and Bainville. Wolf Point was found to be the best site, with about 50 feet of available head and a capacity of 40,000 kilowatts. Based on 1969 prices, the total investment cost was about $101,000,000; based on a 4.875 percent rate of interest and a 100-year amortization period, the benefit-cost ratio was about 0.2 to 1. Because power generation would result in fluctuating water levels at the reservoir, recreation or fish and wildlife benefits would have been negligible. Power benefits would be greater at current price levels; however, they would be offset by higher construction costs and a higher rate of interest. Further consideration is not warranted.

TAILWATER LOWERING

65. Artificial lowering of the tailwater would increase power production by increasing the available head at existing dams. The tailwater is controlled, however, at Fort Peck by the structure and by bedrock; at Oahe by the Big Bend pool; and at Big Bend by the Fort Randall pool. An opportunity does exist to increase generation at Garrison, Fort Randall, and Gavins Point, with the greatest potential per foot of lowering at Fort Randall. There, the tailwater could be lowered 10 feet by dredging, at a cost of about $54,000,000 at 1976 price levels. Such a head change would increase dependable capacity about 42,000 kilowatts and would increase average annual energy about 165,000,000 kilowatt hours; however, the benefit-cost ratio would be only 0.4 to 1. Dredging did not extend far enough downstream to reduce flood damages upstream of the Niobrara River. Similar plans at Garrison and Gavins Point showed even less promise, consequently, this idea has been dropped.

ADDITIONAL UNITS

66. The existing installation at the main stem dams utilize virtually all of the available water supply for hydro-power generation,

with the exception of very wet years such as 1975 when some spills occur. Their minor importance may be judged by the fact that spills are required at Gavins Point 22 percent of the time while the remaining projects range from five percent to zero. Even so, additional units could be used to good advantage by repatterning discharges to increase peak generation and decrease base load operations.

67. Fort Peck, Garrison, Oahe and Fort Randall have outlet works initially installed for release of flood storage. Today, with diversion of the river accomplished and all projects complete including gated spillways, with the tandem accumulation of 16,400,000 acre-feet of flood control storage fully effective, and with the reliability of the electrical transmission grid well demonstrated, these tunnels are available for installing of power turbines at essentially no detriment to the flood control function. This alternative was retained for further consideration.

68. A major function of the Gavins Point project is to provide regulation of flows in the lower river for navigation, water supply and flood control. Pronounced fluctuations in discharge would be incompatible with these purposes; even with some energy recoverable from spills, preliminary study showed economic feasibility of additional units to be sub-marginal. No further investigation was made of Gavins Point.

69. Average releases from Big Bend on a weekly or longer basis are determined by the desired summation of system outflow plus change in Fort Randall storage. During the navigation season, flows typically range from 20,000 to 30,000 cfs; during the non-navigation season, which may exceed half the year in prolonged drouth cycles, discharges typically range from 6,000 to 8,000 cfs. The existing discharge capability of Big Bend is 103,000 cfs, which translates to a plant factor of six to eight percent, or if operation

is confined to five days a week, a plant factor of eight to eleven percent. Four direct intake units of the same design as the present installation would be the most economical addition at Big Bend; however, this would lead to a generating cycle of less than two hours per day. An alternative plan was the installation of reversible pump-turbines which would use the Fort Randall pool as an afterbay. This arrangement would be inoperable in the very period of greatest need - the non-navigation season - because at that time the Fort Randall pool would be too low to make pump-back possible. The Fort Randall pool elevation could be held up during the non-navigation season, but only at the expense of curtailing by half the corresponding seasonal plant factor at Oahe. Further consideration of Big Bend was discontinued.

PUMPED STORAGE PROJECTS

70. Map studies indicated nearly unlimited opportunities for pumped storage hydro-power plants adjoining the main stem reservoirs and 150 sites were individually identified based on head, storage volume, embankment, and location criteria. Of these, about one-fifth were selected for reconnaissance scope determination of their potential hydro-power capacity. Fifteen sites, three at each of the main stem projects except Gavins Point, were selected, based on capacity and probable economy of construction, for preparation of reconnaissance scope cost estimates. The capital cost of these projects which showed potential capacities of 360 MW to 1380 MW varied from approximately $200 per kilowatt to $600 per kilowatt. Four of the fifteen sites appeared more favorable than the others, based on a combination of factors including head, tunnel length, land requirements, and capital cost per kilowatt. Conceptual designs were prepared and estimates of cost were refined for the four sites. All four indicated economic feasibility, and they were retained for additional analysis.

LOAD MANAGEMENT AND ECONOMIC INCENTIVES

71. The electric utility industry today is confronted by a growth rate which although showing modest signs of flattening is still exponential in shape, and by construction costs displaying similar agility. This has caused an active search for ways to meet customer needs with minimal additions to generating plant. "Ripple control" is an effort to restrict delivery of energy over the peak to loads which can be interrupted without undue inconvenience Water heaters are the classic example, a study funded by the Federal Energy Administration suggests that such control can reduce a utility's peak load by ten percent.

72. Load management is complemented by economic incentives modeled after either the carrot or the stick. The hallowed structure whereby rates decline as usage grows has been halted or even reversed for many consumers. For the householder, this is an incentive to reduce _all_ use; ripple control affords a more selective mechanism for reducing _peak_ use. Larger customers, who habitually have paid a demand charge, have always had an incentive to level their peaks and valleys; load management has the additional potential to reward a commercial user who desynchronizes his own peak use from that of the utility system.

73. Load management and economic incentives are harbingers of an American future unavoidably committed to frugality and conservation of resources. Nevertheless, they are not considered further in this report. At their most efficient, neither device is reasonably expected to cause an absolute decline in electrical demand in this century, only a slowing in its rate of growth. This slowing will be reflected in delayed construction of some units of electrical generation, not a freeze on all construction. The most cost effective and environmentally sound units can be expected to appear first; it is against these criteria and not against a concept of no requirement for additional energy that further analysis of hydro-power

will be weighed.

THERMAL GENERATION

74. Since continuation of this nation's economic and social structure in a pattern at least tolerable to its citizens implys some growth in electrical demand as long as population grows - and probably for a number of years beyond that time - one must assume that demand will be met. A number of research efforts are aimed at expanding possible methods: windmills, ocean currents, solar cells, and nuclear fusion, to name a few. Some will doubtless play an important role in future technology; none is a feasible alternative within the time frame of this study.

75. The determination of what is a feasible alternative to proposed hydro-power additions has been made by the Federal Power Commission. On the premise that construction would be geared to meet load requirements of the mid-1980's, the Commission staff found the alternative would be one of several thermal sources with a present-day state of the art capability. Evaluations were made of generation using nuclear, coal, and lignite-fueled steam turbines and oil-fired combustion turbines. The latter were picked as the most likely alternative to hydro-power contributions to area loads as proposed in this study. Oil-fired combustion turbines were, therefore, retained for further analysis.

Recreation, Fish and Wildlife

76. A number of possible solutions were developed in response to five problems or opportunities in the area of recreation, fish and wildlife.

- Remedy sediment problems at boat facilities by periodic dredging.
- Relocate facilities with problems.
- Abandon facilities with problems.
- Re-establish trophy fish population in Lake Oahe and Lake

Francis Case by increasing hatchery capacity.

- Re-establish trophy fish population in Lake Oahe and Lake Francis Case by construction of subimpoundments for rearing.
- Re-establish trophy fish population in Lake Oahe and Lake Francis Case by construction of on-site rearing ponds.
- Improve lake shore and littoral habitat to increase forage base and spawning and nursing habitat at Lake Oahe and Lake Francis Case.
- Introduce substitute species in the lakes.
- Designate and develop Gavins Point to Ponca State Park reach of the Missouri River under the Wild and Scenic Rivers Act.
- Develop cooperative access and recreation sites throughout the bank stabilization works under PL 89-72.
- Improve access to Fort Peck public use areas by Corps effort.
- Improve access to Fort Peck public use areas under authority of PL 93-643.

SEDIMENT PROBLEMS

77. There are currently over one hundred recreation boat ramps and seven boat basins on the main stem lakes. The ramps and basins located in the upper end of the lakes and the lakes' major tributary bays are being adversely effected by sediment deposition. This deposition was anticipated at the time these facilities were planned; however, their need in those locations became the overriding consideration. Other ramps and basins, located on the main body of the lakes, are also subject to sediment accumulation caused by site-specific littoral currents in combination with unstable shoreline slope in the vicinity. These sediment problems were less predictable at the time of construction. All of the boat facilities under discussion were either designed and constructed by the Corps of Engineers or their design and specific location were subject to

approval by the Corps of Engineers.

78. At present, periodic removal of the accumulated material is sufficient maintenance to keep the boat facilities usable. It is predicted, however, that as sediment deposition in the main stem lakes progresses the frequency of need for sediment removal will be increased, creating an increase in cost of the operations and an increasing challenge to find environmentally satisfactory disposal sites. It will become necessary, ultimately, to relocate or abandon some of these facilities. Decisions concerning specific boat facilities will be made during the individual lake project's recreational master plan revisions, indicating appropriate action to be taken by the Corps of Engineers. This procedure does not require additional authorization or significant consultation with other agencies; therefore, the problem is not to be discussed further in this report.

REMAINING PROBLEMS AND OPPORTUNITIES

79. With the exception of those associated with sediment problems at boat facilities, all of the alternatives itemized in paragraph 76 were retained for further consideration.

No Federal Action

80. Under six functional categories, this section has identified a number of possible solutions to problems and needs. In addition, there exists for each of the six the alternative - although in most cases it is not a solution - of no Federal action. This alternative assumes a continuation of current trends in the use and development (or loss and degradation) of resources, and that no new Federal actions will be taken as a result of this study. A determination must be made for each resource category as to what conditions and effects will result if no Federal action is taken. This makes it impossible to establish a baseline from which to measure impacts of alternatives and of the recommended plan. The results of no Federal action will vary: some activities, such as bank stabilization or national wild, scenic, or recreational river designation, appear to require direct Federal

involvement or some form of joint Federal-State actions. Other activities, such as additional electrical generation, seem likely to occur with or without Federal initiative. "No Federal Action" should not be equated with a continuation of present conditions for most resource categories. Lack of bank stabilization, for example, will not preserve the river in its present state. Rather, it will preserve a regime of continuing change; and while the river will remain attractive and natural-appearing in some respects, unique and valuable islands, sand bars, wooded areas, and farmlands will be lost.

Alternatives Considered Further

81. To avoid needless repetition, only those possible solutions which did not survive preliminary screening have thus far been the subject of anything beyond a cataloging of their existence. Only sufficient detail was furnished to explain why those which dropped out did so. The following paragraphs will discuss the remaining alternatives and reduce them still further, leaving a manageable group for final analysis in the selection of a plan.

Flood Control

82. During the period of high inflow to Lake Oahe in 1975, lowland flooding focused attention on the Oahe headwater delta. Backwater analysis and a study of the upward shifts in the Bismarck rating curve indicated that the delta's effect was being felt upstream and indicated a need for upstream extension of the Oahe project lands. Since this action can be accomplished under existing authority it was not considered further in this study. This area downstream of Bismarck is discussed further in the section on waterlogging.

83. Starting in 1969, flood control releases from the upper Missouri River reservoir system, via Fort Randall Dam, caused the surface inundation of agricultural lands along a 10-mile reach upstream from the mouth of the Niobrara River (Missouri River mile 849 to 859). Significant inundation occurred in 1969, 1971, 1972, and 1975 and marginal inundation in 1970. Total inundated acreages, including some low chute or bottom lands, varied from about 1,750 acres with a discharge of 50,000 cfs in 1969 to 2,500 acres with a discharge of 60,000 cfs in 1975. About two-thirds of the acreage is located on the right bank in Nebraska and one-third on the left bank in South Dakota. Sustained inundation started as early as May in 1971 and continued through November in each year; it not only curtailed crop growth, but also prevented the harvest of salvageable produce in some instances. The lack of adequate subsurface drainage on some land prevented the continuation of farming operations due to the saturated condition of the soil.

84. The basic cause of this flooding and waterlogging is a reduction in the channel capacity of the Missouri River attributable to the presence of the main stem reservoir system. Prior to closure of Fort Randall Dam in 1952, the heavy sediment contributions produced from the Niobrara River basin were periodically flushed downstream during the main stem March or June floods. However, from 1953 to 1969, the mean daily flows of the Missouri River at Niobrara were usually 30,000 cfs or less as all flood volumes were retained to fill the reservoir system. Also during this period, above normal sediment yields from Niobrara entered the Missouri channel. This combination of low flow and high sediment yield has resulted in a rise in the normal river stages of at least five feet at the confluence of the Niobrara and an associated reduction in bank-full channel capacity from about 120,000 cfs to under 60,000 cfs.

85. A number of landowners on the Nebraska side of the river have joined to sue the United States, alleging a taking of certain real estate interests. In July of 1976, the United States Court of Claims

found in favor of the plaintiffs, ruling that the Government had acquired a flowage easement over the lands in suit. The United States has filed a motion for rehearing. Pending final resolution of this issue, no courses of action are available to the Corps of Engineers in this study beyond a documentation of the facts, as set forth above. Congress, however, has the authority to legislate relief measures in response to that documentation if deemed appropriate.

Navigation

86. A number of Congressional directives, itemized in Section A of this Appendix, have requested the Corps of Engineers to conduct further studies of expanded navigation on the Missouri River, including new facilities such as locks, marine railroads, and boat elevators. A Review Report, Missouri River, North Dakota, South Dakota, and Nebraska 1965 responded to the Congressional request; it was returned by the Secretary of the Army to OCE in 1969; the field furnished supplemental information to OCE in 1970. The report was subsequently returned to the Omaha District for further coordination of environmental aspects of the navigation-bank stabilization plan.

87. Recent revival of interest in extending the head of navigation may be traced to several factors. Farmers and grain buyers in North Dakota and South Dakota are seeking lower transportation costs for their agricultural products; some see navigation as a means to obtain these lower tariff rates. A second and major stimulus to a fresh look at navigation's future has been the growing national awareness of the vast coal and lignite resources available in North Dakota, Montana and Wyoming. Movement of both agricultural commodities and coal have attracted interest not only in the Missouri basin but in the Mississippi valley as well. The Old West Commission was urged, in the spring of 1976, to sponsor further studies of Missouri River navigation as an impetus to broadened trade for both

regions.

88. This study has re-examined two routes extending navigation above Gavins Point Dam. One route follows the Missouri River using three alternative locations for head of navigation, namely: Chamberlain, South Dakota (in the upper reach of Lake Francis Case); near the mouth of the Yellowstone River (in the upper reach of Lake Sakakawea); and Fort Benton, Montana. The second route follows the James River (from the mouth, seven miles downstream from Yankton) to the vicinity of Jamestown, North Dakota, and thence westerly to Lake Sakakawea. Upstream of this point the Missouri River route was followed to Fort Benton.

EVALUATION PROCEDURES

89. Subsequent to authorization of the existing navigation project by the 1958 Rivers and Harbors Act, almost every investigation of an extension has had difficulty in showing feasibility. In the present screening, to determine whether large scale movement of coal would alter project economics, initial assumptions concerning benefits, permissible tow size and locking efficiency were made deliberately optimistic. The rationale was that if optimistic screening showed possible feasibility, the project could be evaluated in more detail; if it clearly showed infeasibility much needless effort would have been spared.

90. Head of navigation was determined by its general proximity to low sulphur content bituminous coal. Northern Great Plains Resources Program estimated a 160-billion-ton reserve to be in this area, with 103.9 billion tons recoverable. Costs associated in the transporting of this commodity would be eight mills per ton-mile by rail (from a 1976 study by the Bureau of Mines) and three mills per ton-mile by river navigation (Mississippi River rates).

91. Construction costs for the locks and dams are based on the

actual construction costs of the Illinois River project, updated to 1976 level. The construction period was set at 15 years and the economic life of the project was 50 years, with an interest rate of 6-3/8 percent.

92. A tow of 12 barges (open hopper barge 195 ft X 35 ft) with a configuration of 4 X 3 requires a lock of 1,200 feet by 110 feet, with an assumed locking time of 40 minutes. Each tow would transport 18,000 tons. This size tow was considered the maximum size that could operated on the Missouri River in the reach from Kansas City to Sioux City. Planned passing areas would be needed to handle tows of this size.

ROUTES CONSIDERED

93. Following the Missouri River to the mouth of the Yellowstone requires extension of the existing navigation project at Sioux City by channelization and bank stabilization as far as Gavins Point Dam. From this point a total of 10 locks would be required to navigate past the five main stem dams; one at Gavins Point; two at Fort Randall; three at Oahe; one at Big Bend; three at Garrison. Six locks and dams would be required to provide slackwater navigation in the river reaches between the existing main stem dams.

94. The James River route to the Yellowstone would utilize a Missouri River navigation and bank stabilization project as far as the mouth of the James River, about seven miles downstream from Yankton. Following the James River valley to the vicinity of Jamestown, North Dakota, the project would provide a slackwater navigation channel including 14 locks and dams with an average lift of 50 feet. From Jamestown, 100 miles of canal would be constructed in a westerly direction to Lake Sakakawea.

95. The extension of the two routes from Lake Sakakawea to Fort Benton, Montana, following the Missouri using slackwater navigation

would require 16 locks and dams and three locks at Fort Peck.

96. A study was made to evaluate a shorter navigable route in combination with railroad transportation of coal from the Wyoming coal fields. The area considered for earliest development of export coal in Wyoming lies directly west of Chamberlain. This route would follow the same route as the Sioux City-to-Yellowstone River route and would require only three locks at the main stem dams; one at Gavins Point, and two at Fort Randall. Only two open river locks and dams would be required. The coal would be transported to the head of navigation at Chamberlain by rail 407 miles from the coal fields.

97. Extending navigation only as far upstream as Yankton was studied to determine feasibility of navigation based on the generation of upbound and downbound traffic from the trade area. The project would be a combination of navigation-bank stabilization construction. Since bank stabilization without navigation is a separate alternative under consideration in this report, its cost has been treated as separable and is not included in the cost of navigation works, either to Yankton or farther upstream.

ALTERNATIVES TO LOCKS AT THE MAIN STEM DAMS

98. Several alternatives to locks at the main stem dams were considered even though there has been no experience in the United States with design and operation of structures this large. Consequently, methods being used or considered on European inland waterways were evaluated, such as ship elevators, water plows, steel tubs and marine railroads. These different methods of transporting barges over existing dams moved only one barge at a time and thus were considered inadequate to the needs of this study because of the time required to lift or lower a tow of 12 barges.

ECONOMICS

99. Table D-1 presents an estimate of the gross capital investment

and annual costs for the several plans studied for the extension of navigation above Yankton, South Dakota, based on an economic life of 50 years. Annual benefits are also given for each condition. In every alternative the optimistic assumption was made that the navigation project would induce enough coal shipment to keep the locks in operation one hundred percent of the time. With a locking time of 40 minutes, the capacity of the project is 18 tows per day at 18,000 tons per tow or 324,000 tons per day. Economic benefits attributable to the alternatives thus become the savings from moving 324,000 tons of coal every day of an eight-month navigation season, or eighty million tons a year by a combined water-rail route as compared to an all rail route. The cost of transfer from hopper car to barge was ignored in this analysis.

100. Large coal reserves identified in the Northern Great Plains Resources Program report were used in this benefit analysis. Coal being shipped to a head of navigation at the mouth of the Yellowstone River or at Chamberlain, South Dakota, was evaluated as originating in the Sheridan, Gillete, Colstrip complex in northern Wyoming and southern Montana. Rail distance to Sioux City was taken as 611 miles, resulting in an all-rail rate of $4.89 per ton. For shipment to the headwaters of Fort Peck, downstream of Fort Benton, Montana, the coal source was located in Musselshell, Yellowstone and Rosebud counties in Montana, a rail distance of 870 miles from Sioux City, resulting in an all-rail rate of $6.96 per ton.

101. Because of the legal and administrative obstacles presently blocking operation of slurry pipelines, as well as a lack of performance experience for their large-scale operation, this study did not attempt to evaluate pipelines as an additional alternative. Some studies have suggested they have little cost advantage over shipment by unit train, others indicate they could move coal at a cost of three mills per ton-mile - the cost used in this study for barge transport. This study is not sensitive to the actual efficacy

TABLE D-1 — ECONOMIC ANALYSIS FOR

CAPITAL COSTS

1	DIRECT COSTS	
2	NAVIGATION CHANNEL, SIOUX CITY TO GAVINS POINT - 79 MILES ($ MILLION)	
3	LOCKS AT MAIN STEM DAMS ($ MILLION)	
4	INTERVENING LOCKS AND DAMS ($ MILLION)	
5	CANAL CONSTRUCTION ($ MILLION)	
6	CONTINGENCIES - 20% ($ MILLION)	
7		TOTAL DIRECT COSTS ($ MILLION)
8	INDIRECT COSTS	
9	ENGINEERING AND DESIGN ($ MILLION)	
10	SUPERVISION AND ADMINISTRATION ($ MILLION)	
11		TOTAL INDIRECT COSTS ($ MILLION)
12		TOTAL FIRST COSTS ($ MILLION)
13	INTEREST DURING CONSTRUCTION - 15 YEARS - 6-3/8% ($MILLION)	
14		GROSS CAPITAL INVESTMENT ($ MILLION)

ANNUAL COSTS

15	ANNUAL CHARGES	
16	INTEREST AND AMORTIZATION 6-3/8% ($ MILLION)	
17	OPERATION AND MAINTENANCE 1% ($ MILLION)	
18		TOTAL ANNUAL ECONOMIC CHARGES ($ MILLION)

BENEFITS

19	RAIL MILES - COAL FIELD TO HEAD OF NAVIGATION
20	RAIL FREIGHT COSTS PER TON - UNIT TRAIN
21	NAVIGATION MILES - HEAD OF NAVIGATION TO SIOUX CITY
22	BARGE FREIGHT COSTS PER TON
23	TOTAL FREIGHT COST PER TON - COMBINED RAIL-BARGE
24	ALTERNATE COST PER TON - UNIT TRAIN - COAL FIELD TO SIOUX CITY
25	SAVINGS - COST PER TON BY RAIL-BARGE - COAL FIELD TO SIOUX CITY
26	ANNUAL BENEFITS - 80,000,000 TONS PER YEAR, COAL FIELD TO SIOUX CITY ($ MILLION)
27	BENEFIT COST RATIO

EXTENDING THE NAVIGATION PROJECT

	MISSOURI RIVER ROUTE SIOUX CITY TO -		JAMES RIVER ROUTE SIOUX CITY TO -		
CHAMBERLAIN	YELLOWSTONE RIVER	FT. BENTON	YELLOWSTONE RIVER	FT. BENTON	
21.9	21.9	21.9	21.9	21.9	2
3ea 438.8	10ea 1489.8	13ea 1992.8	-	3ea 503.0	3
2ea 281.0	6ea 727.0	24ea 2730.0	14ea 1764.0	32ea 3767.0	4
-	-	-	100.0	100.0	5
148.3	447.7	948.9	377.2	878.4	6
890.0	2686.4	5693.6	2263.1	5270.3	7
89.0	268.6	569.3	226.3	527.0	9
89.0	268.6	569.3	226.3	527.0	10
178.0	537.2	1138.6	452.6	1054.0	11
1068.0	3223.6	6832.2	2715.7	6324.3	12
510.6	1541.3	3266.7	1298.4	3023.8	13
1578.6	4764.9	10098.9	4014.1	9348.1	14
105.4	318.2	674.4	268.1	624.3	16
15.8	47.6	100.9	40.1	93.4	17
121.2	365.8	775.3	308.2	717.7	18
407	246	150	246	150	19
$3.26	$1.97	$1.20	$1.97	$1.20	20
235	850	1341	780	1271	21
$0.70	$2.55	$4.02	$2.34	$3.81	22
$3.96	$4.52	$5.22	$4.31	$5.01	23
$4.89	$4.89	$6.96	$4.89	$6.96	24
$0.93	$0.37	$1.74	$0.58	$1.95	25
74.4	29.6	139.2	46.4	156.0	26
0.61	0.08	0.18	0.15	0.22	27

of slurry pipelines; to the extent they reduce cost below that by unit train, they further decrease feasibility of barge transport.

102. A different rationale was necessary in evaluation of a Sioux City-Yankton extension. Sioux City, the present head of navigation is a rail terminal of sizable importance, yet this junction of transportation modes has not resulted in any trans-shipment of western coal, which continues to cross the region by unit train. In this light, it seems unreasonable to suppose that a 75-mile extension of the channel to a site less favorably endowed with rail transport would create new barge traffic in coal. Instead, to remain consistent with the optimistic tenor of other navigation assumptions the Sioux City-Yankton reach was evaluated on the premise that the 400,000 tons of cargo which moved into and out of Sioux City during the record breaking year of 1976 will serve as a proxy for the tonnage in and out of Yankton.

103. A 75-mile extension of the navigation system to the port of Yankton (four miles downstream from Gavins Point) is estimated at:

CAPITAL COSTS		
Navigation channel - 75 miles	$20,800,000	
Contingencies @ 20%	4,400,000	
Total Direct Costs		$25,200,000
Engineering and design @ 10%	2,500,000	
Supervision and Administration @ 10%	2,500,000	
Total Indirect Costs		5,000,000
TOTAL FIRST COST		30,200,000
Interest During Construction 15 yr. @ 6-3/8%		14,200,000
GROSS CAPITAL INVESTMENT		$44,400,000
ANNUAL COSTS		
Interest and amortization @ 6-3/8%	$3,000,000	
Operation and maintenance @ 2-1/2%	1,100,000	
TOTAL ANNUAL ECONOMIC CHARGES		$4,100,000

104. To balance annual charges of $4,100,000 with $4,100,000 in

benefits, while moving 400,000 tons of traffic 75 miles requires a waterborne savings of 137 mills per ton-mile. When actual savings are not one-tenth of that amount, the present infeasibility of this alternative is evident.

CONCLUSION

105. The pro-navigation bias adopted in the foregoing analysis overstated by substantial margins the true capacity of alternative additions to the Missouri River navigation project and understated their costs. Nonetheless, it provided a "failsafe" initial evaluation in accordance with the reasoning that, "If navigation couldn't make it under these conditions, it could never make." Until some major change takes place in the factors influencing cost and benefits, there appears to be little justification for a more detailed evaluation.

Waterlogging

106. Previous analysis has identified three locations within the study area with waterlogging problems attributable, at least in part, to the presence of the main stem reservoir system: the Buford-Trenton area; the area from Bismarck, North Dakota to the boundary of Oahe, and the area bordering the 10-mile reach upstream of the Niobrara River. An examination of the geography and geology of the areas resulted in retention of three alternatives: improvement of interior drainage; acquisition of an interest in the land; and land use planning.

BUFORD-TRENTON IRRIGATION DISTRICT

107. The Buford-Trenton Irrigation District is located along the left bank of the Missouri River in western North Dakota near Williston at the upstream end of Lake Sakakawea immediately downstream of the confluence with the Yellowstone River. It was developed with joint assistance from the Bureau of Reclamation and the Department of Agriculture in the early 1940's. The District

is divided by bends in the Missouri River into four areas: East, Middle, West, and Zero Bottoms. When fully developed, the project consisted of about 16,800 acres, about 10,000 of which were irrigable.

108. The possibility of future problems at Buford-Trenton effected by Lake Sakakawea was anticipated in early planning for the Garrison project. In response to a Congressional request, a report entitled "Protective Works in the Williston Area of the Garrison Reservoir" was completed in December 1953. Although this report was never submitted to Congress, the Public Works Appropriation Act of 1955 (Public Law 84-163) did subsequently provide funds for purchase, in lieu of protection, of the East Bottom of the Buford-Trenton Irrigation District, and also the Lewis and Clark Irrigation District, a 7,700-acre project across the river. In addition, the Act included funds for protection of the intake structure of the Buford-Trenton pumping plant in Zero Bottom and for construction of bank protection to prevent erosion along the Missouri River adjacent to the District. The necessary protective works were completed in 1961 at a total cost of $1,200,000.

109. Purchase of the East Bottom by the Corps of Engineers in 1958 reduced the total acreage of the Buford-Trenton District to about 10,200 acres and the irrigated acreage to about 7,100 acres. Because of the effect of this reduction in size of the District on the cost-per-acre of operation, the outstanding repayment costs for construction of the project were, by the Appropriation Act of 1957, declared non-reimbursable for the remaining portion of the project. The Department of Interior was authorized and directed to enter into a contract with the Buford-Trenton Irrigation District which would provide for a transfer of the operation and maintenance responsibility of the project works to the District. Title to the project works in the East Bottom was transferred to the Corps of Engineers and title to the remainder of the project works has remained with the Bureau of Reclamation.

110. The Buford-Trenton Irrigation District has continued to operate and maintain these latter works, furnishing irrigation water, at cost, for the lands in the East Bottom in addition to the water for its own members. Arable lands in the East Bottom, diminishing in acreage, have been leased back by the Corps of Engineers to the East Valley Mutual Aid Cooperative. This group, in turn, subleases the lands to individual operators with the former owners having the first option to lease. The Cooperative also operates and maintains the irrigation facilities in the East Bottom.

111. Since the closure of Garrison Dam in 1958, deposition of sediment to create a headwaters delta in Lake Sakakawea has progressed much as anticipated. Adjacent to the Middle and West Bottoms, water surface profiles of the Missouri River in the 20,000 to 60,000 cfs discharge range are now three to five feet higher than they were a decade ago; however, they exceed pre-reservoir conditions at the West Bottoms by only one or two feet because of the reduction in stages caused by a Missouri River cutoff in 1958. The first organized expressions of concern surfaced in 1967, generated primarily by water in the basements of several farm homes. Since that time, local complaints have been voiced on a more or less continuing basis. In 1970 the Senate Public Works Committee requested the Chief of Engineers to investigate "methods of resolving land use problems in the Buford-Trenton Irrigation District and vicinity, resulting from a high water table."

112. Accordingly, the U. S. Army Engineer District, Omaha, prepared a report on Buford-Trenton Irrigation District and Vicinity, North Dakota, dated June 1974. This report provided several possible solutions together with some reconnaissance-scope estimates of cost. It further indicated that uncertainty exists as to the exact limits of the area affected and of future prospects for those lands not yet affected. The report was confined to the presentation of technical data and did not include conclusions or recommendations. Early in

1976 it was returned by the Chief of Engineers to the Missouri River Division for additional analysis during the course of this study.

113. This re-examination focused attention on four items significant to the formulation of any plan dealing with the future of Buford-Trenton.

- The upward trend in river stage seems to be levelling off since 1971, according to records for discharges in the 20,000-60,000 cfs range. This is attributed to the formation of a deltaic channel that conveys the sediment load through the headwater area, downstream where it deposits to extend the delta into the reservoir.
- The most acute consequence of the rise in river stages is the effect on drainage through the open ditch drainage system in the District. In mid-winter and mid-wummer, rises on the Missouri River have backed water through the ditch system to cause flooding. During the irrigation season the river is often higher than the elevation of the drainage outlet causing water to stand in the drainage system and impede the irrigation return flows, which contributes to the rising groundwater table and the swamping of low-lying areas.
- During the 1975 crop season, in spite of abnormally high flows in the Missouri River, concerted efforts by local farmers to block the ditches in the Middle and West Bottoms near the river and pump down the ditch water level resulted in above-average crop yields.
- Most members of the District do not want to sell out. Rather than part with their lands, they would prefer an interim solution that might prolong the period of economical agricultural operation.

114. In recognition of these factors, the Corps has developed a plan intended to function reliably over a range of Missouri River stages and concurrent interior drainage requirements. In the Middle and West Bottoms earth-fill blocks are proposed near the riverward end of the main drains, with gated conduits to permit gravity drainage during low Missouri River stages. The gravity drain for the West Bottoms will consist of a 72-inch conduit with the necessary emergency

flood gates. In the Middle Bottoms, it is planned that the twin 36-inch conduits that are already in place can be utilized by adding the required flood gates. When stages are higher, the gates will be closed and the water level in the main drains will be regulated by two 3,600 gpm pumps at each installation discharging over the earth block into the Missouri River.

115. This plan has been presented by the Corps during formal meetings of the Buford-Trenton Irrigation District in April and July of 1976 and in April of 1977. It has been indorsed each time as much preferable to land acquisition and meriting a trial. The Corps proposes to design and construct these works utilizing operation and maintenance funds appropriated for the Garrison project, after advising the proper Congressional Committees. Given their clearance, it is planned to have the facilities operational by the start of the 1978 irrigation season. Total cost of the plan is estimated at $500,000.

116. Such a procedure has a number of advantages. A few more years of observation may confirm whether river stages have indeed reached equilibrium or whether they are continuing to rise, and their rate. These answers, in turn, would make possible a more definitive conclusion as to how many additional District lands may be affected and how soon. It is possible that improvement of ditch drainage may prove to be only a temporary solution. If this is confirmed, Congressional authority will have to be sought for the only remaining alternative - land acquisition similar to that carried out at the Lewis and Clark and East Bottom units. In the meanwhile, the drainage plan will have responded to expressed Congressional interest and the test of public acceptability. The cost of acquiring the entire District was estimated in 1974 at ten million dollars. If this represents the capitalized worth of production, the benefit of postponing that production loss for one year at today's interest exceeds the cost of the drainage measures. In actuality, the project is expected to be effective not for one year but for as many as

twenty-five.

117. Since the solution adopted as a result of this study is implementable within existing Corps authority after Committee notification, and no need exists for recommended further action at this time, the on-going planning for improvement of interior drainage is not carried forward into a presentation of the Selected Plan.

BISMARCK-LAKE OAHE

118. The problem of lowland flooding and swamping south of Bismarck during periods of high inflow to Lake Oahe was discussed in paragraph D-82, where it was indicated that an upstream extension of the Oahe project boundary is being studied under existing authority. In addition to these surface waters, the area south of Bismarck has experienced a rise in the ground water table during years past sufficient to cause complaints from some property owners. The area already contains subdivisions and dwellings which presage still further growth. Extension of the Oahe project boundaries would remove some but not all this land from private ownership and the hazard of unwise land use.

119. Four observation wells have been installed to monitor the water table in this area, with the oldest dating back to late 1961. During 14 years of observation the water table measured by this well has risen not quite four feet. Several factors have been identified which may be contributing in greater or lesser degree to this rise; they are now being evaluated as an adjunct to the study of extending Oahe's project boundary.

- During the last seven years of well observation, streamflow recorded at the Bismarck gage has averaged 140 percent of the preceding seven years and also 140 percent of the long-term average covering 46 years. This series of higher than normal flows has resulted in higher than normal stages.

- The rating curve at Bismarck generally shifted upward two to three feet in the years 1952 to 1967 before Oahe Reservoir was filled and, therefore, before Oahe backwater could have been a factor.

- The rating curve at Bismarck generally shifted upward an additional foot after 1967 while Oahe Reservoir has been at full operating level.

- Winter stages at Bismarck since the Garrison power plant began operation have increased by about five feet as a result of increased daily average release rates under ice cover.

120. Reconnaissance studies indicate that landward of the areas inundated by surface water in 1975 there is a belt totaling 2,700 acres where water is within four feet of the surface of the ground. Beyond lie some 8,000 additional acres where the water table is between four and eight feet deep. Most of this area would be inundated by the 100-year flood, which could occur because of high flows out of the Heart or Knife River or because of ice jams which may pose a threat even during periods of considerably lower flow. Some of this acreage could be raised above the 100-year hazard with two or three feet of fill material; this would not be enough, however, to dispel the problem of high ground water.

121. Because these lands are in the path of Bismarck's southward growth, their owners have shown a marked lack of enthusiasm toward zoning them for non-structural uses. During the late 1960's the Corps attempted to implement a Congressional authorization to acquire some holdings in this area for wildlife mitigation for Lake Oahe, but intense local opposition put a halt to the appropriation of funds.

122. **Until on-going studies are complete, no final conclusions can be reached about system effects upstream of the revised Oahe boundary.** Since this problem is being dealt with under existing authority, no additional recommendations are made in this report. Nonetheless, the area needs continuing attention from local authorities as a

problem area calling for careful land use management to prevent unsound development in an area that lies in large measure within the 100-year flood plain.

NIOBRARA REACH

123. Along the Missouri River reach upstream of the Niobrara, any Congressional measures directed toward relieving landowners from surface flooding could accommodate losses from waterlogging as well. The status of litigation in the area imposes the constraint on the Corps of Engineers already described in paragraph D-85.

Bank Stabilization

124. The alternative of soft bank protection, retained for further consideration in this section, responds to a need which was recognized a number of years prior to this study. PL 88-253, the 1963 Flood Control Act, modified the Flood Control Act of 1938, "to include such bank protection or rectification works at or below the Garrison Reservoir as in the discretion of the Chief of Engineers and the Secretary of the Army may be found necessary." In accordance with the Act's legislative history, seven sites were selected for construction in the reach from Stanton to Bismarck, North Dakota, and have been nearly completed.

125. Continuing awareness by Congress of bank erosion problems within the present study area was evident in Section 32 of PL 93-251, the Streambank Erosion Control Evaluation and Demonstration Act of 1974. The Act provided that: "At a minimum, demonstration projects shall be conducted at multiple sites on ---" a total of four designated river reaches within the continental United States. Half of these lie within the compass of this report, specifically: "that reach of the Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa;" and, "that reach of the Missouri River in North Dakota at or below the Garrison Dam." In response to this legislation contracts have been awarded for work at one site in the

Garrison reach and two below Gavins Point, with two and four additional sites in the respective reaches currently being designed.

126. The most recent Congressional expression that bank erosion on the Missouri River is a problem which can and will be solved is contained in Section 161 of PL 94-587, the Water Resources Development Act of 1976. This Section amends Section 32 of the 1974 Act by identifying the work now under contract or design in the Garrison reach through specific river mile and bank designation and by adding 18 new sites designated in similar fashion.

127. From this recitation it is apparent that the citizenry and public officials along the Missouri River have imbued Congress with a belief that bank erosion is a serious problem which deserves remedy. Tangible expression of this belief has continued almost a decade and a half; there is every indication that concern to see the job done is increasing. The methodology utilized thus far - that of direct Congressional response to locally identified problems - has produced results. A drawback does exist; results so produced tend to be piecemeal, with the liklihood of neglecting other areas of equal severity.

128. At this writing, Congressional perception of bank erosion within the study area falls into three categories:

The reach below Garrison, where action has been directed at specific locations

● The reach between Fort Randall Dam and Sioux City, where action has been directed "at multiple sites" to be determined by the Corps of Engineers

● All remaining reaches, which must compete with the rest of the Missouri Basin and of the nation where mandatory action is absent.

129. Specific data are available with which to identify the critical areas within the second and third categories listed above. The

alternatives which remain available within the scope of this report are to analyze that data and to make recommendations aimed toward systematic, efficient and economical completion of the job which Congress has instituted or to provide no input. The latter option will result in a continuation of the authorization and construction processes now going on, not in a suspension of that process. The alternative of no Federal action, which is almost omni-present during the formulation of water resource plans, has little credibility in this instance if past events afford any perspective of the future.

Hydro-Power

130. After preliminary screening, potential hydro-power additions at four of the main stem dams and four locations suitable for pumped-storage were retained for further consideration. The next step was an evaluation of how well each element could be accommodated within the numerous constraints imposed by main stem operations and the regional power load, followed by analyses of project sizing and finally by investigation of alternative impacts on the Missouri River downstream of the affected main stem projects.

ACCOMMODATION TO OPERATING CONDITIONS

131. Paragraph C-59 and Figure C-6 offered a presentation of plant factors at the existing hydro-power installations under depletion conditions ranging from 1970 to ultimate levels. These values were derived by averaging generation over the entire period of hydrologic record, and while they present an informative generalization of the effects of depleted flows on power output they do not suffice for the actual evaluation of possible additions to the hydro system. Since they represent an average of very dry years, very wet years and near normal years, they offer little indication as to how the magnitude or the duration of drouth period flows, when dependable capacity is measured, affect existing powerplants and potential additions.

132. It has been mentioned earlier that dependable capacity of the

main stem system is measured during the fourth year of "the drouth of the '30's," 1933. Project storage and hence project capability averaged over the period 1954 through 1964 closely approximates 1933 conditions. Since an 11-year period is encompassed by this second-most severe drouth of record, it gives a more reliable indication of release patterns than would the inflow-dependent peculiarities of a single water year such as 1933. Table D-2 shows average release rates obtained from operation studies analyzing a recurrence of flows under depletion levels of 7.6, 14.7 and 16.3 million acre-feet per year above Sioux City. The high and low values were reported by the Ad Hoc Committee to be the ultimate depletion level and the level prevailing about 1980. The intermediate of 14.6 maf represents conditions in 2000 as estimated in the State-Regional Future for the National Assessment. Extrapolation of this estimate would indicate the level of ultimate depletions to be reached by 2010.

TABLE D-2 EFFECT OF DEPLETION LEVELS ON DROUTH PERIOD RELEASES

Project	Releases in cfs for the period 1954 - 1964		
	7.6 MAF 1/	14.7 MAF 1/	16.3 MAF 1/
Ft. Peck - annual average	8,200	6,800	5,700
Garrison - annual average	19,000	11,800	8,300
Oahe - Jul - Aug - avg.	26,400	13,800	7,200
Oahe - Dec - Jan - avg.	19,300	14,000	6,800
Ft. Randall Jul - Aug - avg.	26,800	17,600	8,800
Ft. Randall Dec - Jan - avg.	7,300	4,600	6,600

1/ Average annual depletion above Sioux City

133. Table D-2 reflects two distinct operating regimens; one applicable at Fort Peck and Garrison, the other at Oahe and Fort Randall. Discharges from the latter two projects must support the patterning of release targets downstream of the reservoir system, with flows during the navigation season two or more times the magnitude of non-navigation flows. Although the annual peak for this marketing area

has shifted over the years and dependable capacity is now measured at the end of August rather than the end of December, both values have significance in planning additions to serve regional loads. For this reason the average of July and August values is tabulated as representative of the summer peak period while the December - January average is included to show the available water supply during the somewhat lower winter peak.

134. At Fort Peck and Garrison, releases are not geared directly to navigation requirements. Seasonal differences developed during past operation studies have reflected power demands projected by marketing estimates; as future patterns of demand change, (from winter to summer peak, for example) releases can be shifted to accommodate them. Consequently, the average annual water supply available serves as a conservative indicator of power plant utilization. Some opportunity for optimization beyond this level exists; at Fort Peck, for example, the average annual release rate of 8,200 cfs shown in Table D-2 could be shifted to an average of 9,700 cfs for eight months and 5,200 cfs for four months - or any other arithmetic combination which operating conditions made desirable.

135. Based upon the available water supply and constraints on its regulation, Table D-3 shows plant factors corresponding to the release rates given in Table D-2. Values are given for both the existing power installations and for the projects with turbines added to every flood control tunnel (except for two at Oahe, reserved for flood control releases) under sizing procedures described in paragraph D-146 et seq.

136. Information contained in Table D-3 provides a basis for evaluating the role of additions to the existing hydro-power system. Fort Peck, the uppermost reservoir, is little affected by growing depletions, which are in large measure located further downstream. Even without patterning the average annual release in order to serve the months

TABLE D-3 DROUTH PERIOD PLANT FACTORS - EXISTING AND ENLARGED PLANTS

	Plant Factor in Percent		
	7.6MAF 1/	14.7MAF 1/	16.3MAF 1/
Fort Peck annual average			
Existing	55	51	49
Enlarged	26	24	23
Garrison annual average			
Existing	51	35	27
Enlarged	30	21	16
Oahe July - Aug. average			
Existing	53	21	16
Enlarged	41	16	12
Oahe Dec. - Jan. average			
Existing	37	20	15
Enlarged	29	15	11
Fort Randall July - Aug. average			
Existing	67	40	24
Enlarged	36	22	13
Fort Randall Dec. - Jan. average			
Existing	18	13	18
Enlarged	10	7	10

1/ Average annual depletion above Sioux City

of peak demand, there is projected to be enough water under the ultimate depletion level to peak for 5-1/2 hours per day. At Garrison, the effect of increased depletions will be felt more strongly; declining flows may be expected to reduce plant factors for both existing and enlarged installations by nearly half. Even so, the enlarged installation will be able to average four hours of generation daily through a recurrence of the 1954-64 drouth period; modest utilization of inherent flexibility in patterning monthly releases to peak demand could insure six hours of generation during periods of highest demand.

137. It has already been noted that Oahe and Fort Randall cannot be responsive solely to the need for power generation; they must also support requirements for system outflow. Moreover, these projects feel most acutely the impact of reduced streamflow, with plant factors under ultimate depletion levels dropping to one-third of their early values. While all other values in Table D-3 decline along with a declining water supply, the December - January plant factor at Fort Randall is higher with 16.3 million acre-feet of depletion than with 14.6. This results from a shift in system objectives in the study of ultimate depletions. The navigation function was regarded as no longer viable under these conditions; with its discontinuation went the need to store winter flows for summer use, as shown by the forty percent decline (40 to 24 and 22 to 13) in the July - August plant factor.

138. The plant factors shown in Table D-3 indicate that with ultimate depletions and 1954-1964 average flows, Oahe and Fort Randall could generate between two and three hours per day. The critical question not answered by the table is that of timing - do the additions have a good prospect of recouping their capital investment before such constraints occur? Paragraph C-43 through C-48 discussed estimates of depletion growth developed by the Ad Hoc Committee and extending to 2060. Paragraph D-132 indicated the projection in the State Regional future that near ultimate depletions could occur by the turn of the century. Within estimates of such wide range, it is not possible to formulate additions to the Fort Randall and Oahe powerplants with any assurance of their economic feasibility. If Ad Hoc growth rates are sound and depletions less than ultimate prevail until 2060 or beyond, the plants will have long since been amortized, a feat which is impossible of accomplishment by the year 2000.

139. One of the findings of this report is a need to identify priorities in water use, develop costing an marketing policies a

document water rights. Such an effort could be expected to narrow materially the present divergence in estimates and to make possible an evaluation of additions to the Fort Randall and Oahe power projects in consonance with a recognized water use policy. Failing this, a further observation of the rate of unregulated growth in main stem depletions would of itself provide a somewhat better gage of the more remote future than is presently at hand. In view of these uncertainties, additions to Fort Randall and Oahe have been deferred from further consideration in this study. It is recommended that they be reviewed immediately following the establishment of a joint State-Federal water use policy for the upper Missouri basin, or in any event not later than 1985, and that recommendations as to their disposal be made in accordance with conditions then perceived.

140. Documented here, for consideration when these projects are re-evaluated is the operational flexibility inherent in Oahe because of the downstream location of Big Bend. Except for some detriment to fishing success at Pierre and a modest reduction in the elevation of Big Bend, Oahe Reservoir can be shut down on week-ends without problem, thereby providing increased releases during the remainder of the week. A comparable operation would be very detrimental in the 45 miles of open river below Fort Randall.

141. Additions to the Fort Peck and Garrison power plants which showed viability whatever the rate of depletion growth, were retained for additional analysis.

142. While main stem power projects and any future additions to them must be assessed in light of the vagaries of their water supply, a different set of factors affects the addition of pumped-storage hydro-power to the system. Given enough forebay sites, the total of pumped-storage additions is limited by the availability of surplus energy for off-peak pumping operations and the ability

to provide an adequate transmission grid. In contrast to conventional patterns of power distribution, the transmission net centered around a pumped-storage plant must be capable of moving in to the plant half again as much energy as it is designed to move out, and the suppliers of this energy may be more diverse and remote than is the conventional load.

143. Reconnaissance investigation of potential pumped-storage sites narrowed the field to two at Fort Peck with gross heads of 950 and 470 feet, each sized at about 1,200 mw; one at Lake Sakakawea with 350 feet of head and 700 mw; and one at Lake Francis Case with 710 feet of head and installation of 1,200 mw. These study results were presented to the marketing agency for further analysis. The Bureau of Reclamation found pumped-storage sites at Fort Peck to be too remote from load centers in the Missouri basin to make possible reliable power transmission, particularly to headwater locations, without losing financial feasibility. These sites were dropped from further consideration.

144. At Garrison, strengthening of the existing transmission grid to accommodate pumped storage in the near term would impose the same financial problem reported at Fort Peck -- inability to repay costs within fifty years. The Bureau did identify two factors which could improve future prospects for this option: exploitation of the large coal and lignite deposits in North Dakota by building additional thermal generation would require corresponding increases in transmission facilities, and the base-loaded coal plants could market off-peak energy to the pumped-storage facility. The Bureau suggested re-examination of this alternative subsequent to 1985 in the light of actual development experienced. This report, accordingly, proposes that construction of pumped-storage at Garrison as well as additions to the Oahe and Fort Randall power plants be reviewed in the mid-1980s as to their potential role in the marketing area as it then exists.

145. The pumped-storage project adjacent to Lake Francis Case was designated as the Gregory County project. All elements of the project appeared favorable and it was retained for further study.

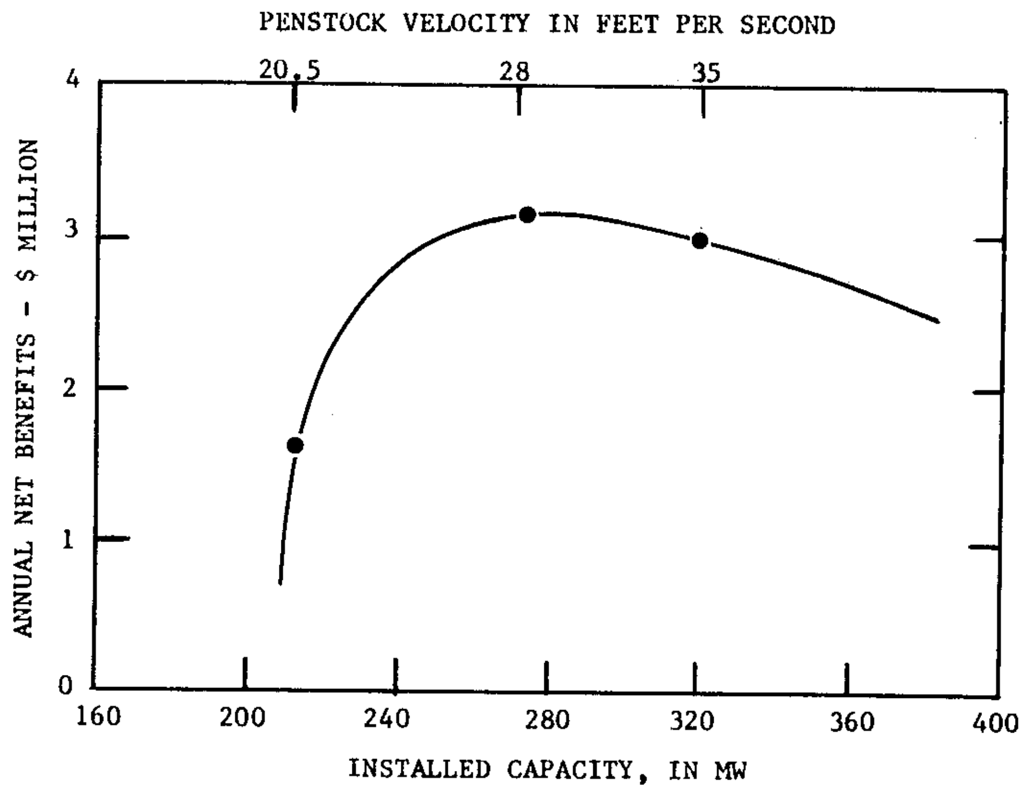
PROJECT SIZING

146. Additions to the main stem projects have been planned to take advantage of flood control conduits already in existence. Consequently, not every consideration required of the planner of a completely new installation is applicable to this analysis. Critical head has already been established; the maximum number of units is fixed by the number of existing conduits; the procedure for determining dependable capacity has been accomplished. Two areas of latitude do remain, however: what size should individual units be and how many of the available conduits should be utilized for power generation. The pumped-storage alternative, of course, is a completely new installation and selection of the project size and plant factor are unconstrained by existing project features.

147. Given a power conduit of fixed dimension, turbine output may be increased by permitting conduit velocities to increase, but not without cost. Head losses also increase and energy production declines; beyond a certain limit the available wattage will start to decline as well. Contact was made with a leading turbine manufacturer to obtain the data necessary for optimization studies involving various velocities. Since the manufacturer had no data for velocities higher than 35 feet per second, that value was accepted as an upper limit. At Garrison this limitation proved inconsequential; as shown in Figure D-1 the point of optimization was reached at a lesser velocity. The further alternative of using one or two rather than all three available conduits was discussed with staff of the Bureau of Reclamation. They expressed a need for all available capacity; moreover the full installation maximizes net benefits. Since both the marketing requirements and economic formulation were best met by so doing, the Garrison addition was sized

at three units totaling 272 mw.

Figure D-1 OPTIMAL PLANT SIZING - GARRISON



148. At Fort Peck, the opportunity to optimize net benefits in like fashion was limited by structural considerations. It is proposed to locate the additional units in a third powerhouse adjacent to powerhouses one and two. Slope movement in this area was observed during excavation for the outlet works in 1934 and has continued. Because of this, it was considered impractical to require removal of any part of the right basin stilling wall. These limitations on powerhouse size, and the excavation depths necessary in its construction, limit, in turn, the size of the machinery installed. Sverdrup &

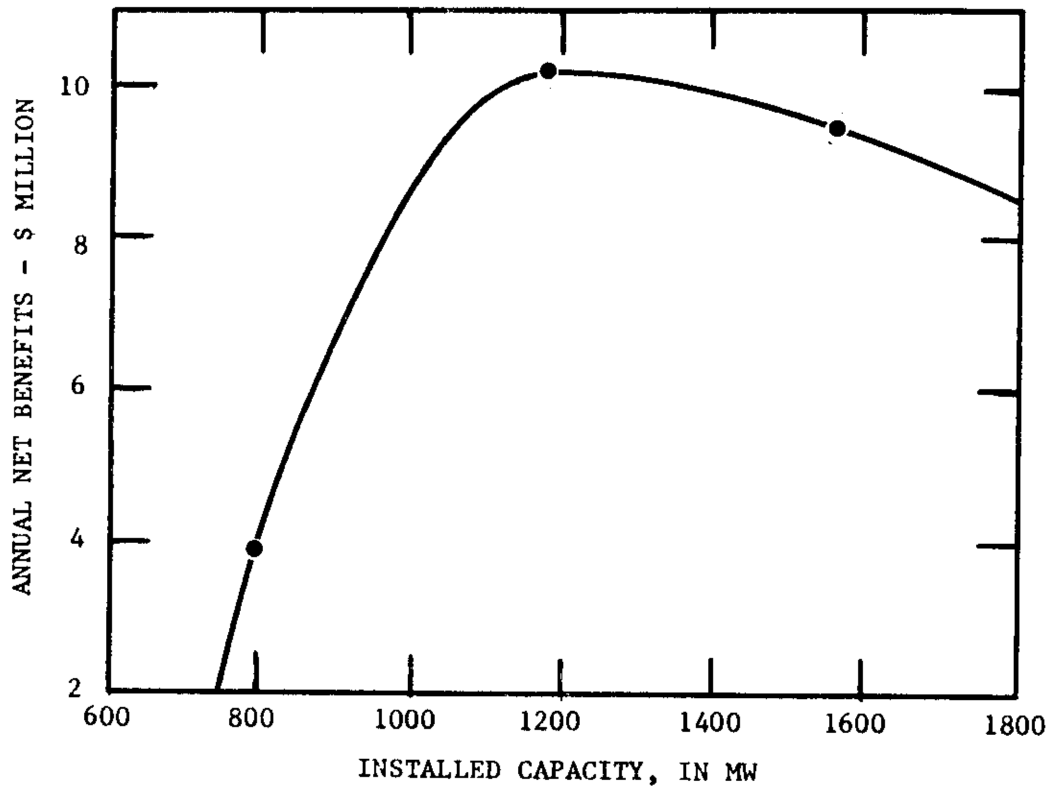
Parcel and Associates, Inc., in their Preliminary Study, Additional Hydro-power prepared in 1973 under contract with the Omaha District, fixed this maximum at two units of 92.5 mw each. The limitation has been observed in this study.

149. Here, as at Garrison, there exists an option concerning the number of units to be added. Initially, the Corps gave serious consideration to the recommendation of one unit without a reregulation structure (discussed in Para. 152). This configuration would increase power plant releases by 57 percent rather than 114 percent. It was felt that the single unit could be used in a prototype evaluation of the effects of increased peaking discharges, with the possibility of adding a second unit, should environmental concerns fail to materialize. Both the State of Montana and the Fish and Wildlife Service, during the course of a public meeting on study results held at Great Falls, took strong exception to this procedure. Both said the Corps was temporizing - to the detriment of power production and of the riverine environment as well. Hence, the two-unit concept was adopted, together with an analysis of lessening downstream effects.

150. In sizing Gregory County, the first limitation to be observed was the availability of pumping energy. The Federal Power Commission's estimate that 1,500 mw of pumped-storage generation could be supported by the time design and construction were accomplished has been verified by the marketing agency. The hours of operation, which affect forebay sizing, were set at ten per week day, again by mutual agreement as the shape of the load curve. Although a point of diminishing returns had not been reached at penstock velocities of 35 feet per second, this value was used for design in the absence of additional data. Further optimization studies of this aspect may be warranted during advanced design. Subject to the above constraints, three installations sized at approximately 800, 1,200, and 1,600 mw were costed in detail. The resultant relationship

between size and net benefits is shown in Figure D-2. The 1,200 mw project was selected for further study.

Figure D-2 GREGORY COUNTY PUMPED-STORAGE PLANT
SIZE OPTIMIZATION



151. During the series of public hearings on study findings the Corps was presented with an alternative at Gregory County which had not been previously considered. Sparked by drouth conditions in the area, representatives of several communities and agricultural areas requested the incorporation of municipal and rural water supply and irrigation water to be obtained from the Gregory County forebay. The proposal was retained for further study.

ALTERNATIVE TREATMENT OF DOWNSTREAM EFFECTS

152. One consequence of increased power plant capacity at existing

projects which has previously been noted is a change in discharge regime, with higher high flows and lower or more prolonged lows. These fluctuations can be reduced to a large extent by the construction of downstream reregulation reservoirs. Such a structure would be designed to receive the widely varying flows and store them for release at a uniform or nearly uniform rate. At both Fort Peck and Garrison the potential exists to install such structures and they were retained for further consideration. At Gregory County no need exists, since power discharges would be made directly into Lake Francis Case.

SUMMARY

153. Screening conducted in the study to this point left the following alternatives from which to choose hydro-power elements of the selected plan:

- Addition of 185 mw at Fort Peck with or without reregulation
- Addition of 272 mw at Garrison with or without reregulation
- Construction of 1,180 mw of pumped storage at Gregory County with or without multiple-purpose water supply as a project function.

Recreation, Fish and Wildlife

154. This phase of the study eliminated three possible opportunities in the area of recreation, fish and wildlife from further consideration:

- Re-establishment of trophy fish population in Lake Oahe and Francis Case by construction of subimpoundments for rearing
- Introduction of substitute species in the lakes to reinstitute trophy fishing
- Improvement of access to Fort Peck public use areas

155. Two alternative methods of satisfying the objective of restocking trophy fish have already been identified: rearing subimpoundments or rearing in hatchery facilities. The cumulative effect of several factors ruled out further consideration of

sub-impoundments:

- Embankments and flow structures designed to function throughout the range of main reservoir elevations are elaborate and expensive.
- The contributing drainage area makes sub-impoundments vulnerable to sediment deposition.
- Cold spring rains or significant snow-melt inflow pose the threat of high fish mortality resulting from sudden temperature changes.
- Establishment of plant growth to support a forage base is more difficult in a sub-impoundment where both soil and water level are less subject to optimal management.

156. Several new fish species have recently been introduced into Lake Oahe by the State. These include kokanee salmon, lake trout, and brown trout. **Some of these species have the potential to** become permanently established and would represent a definite asset to the lake fishery, adding to the diversity of species. However, indications are that these species in large lake environments tend to occupy the deeper and more inaccessable parts of the lake. Under these circumstances specialized tackle and equipment are needed for fishing success; consequently, these fish cannot be considered available to the average visiting fisherman. It is concluded then, that despite the desirability of introducing new species, such action is a complement to the re-establishment of northern pike rather than an alternative.

157. Residents of the Fort Peck area have for years cited the lake as a neglected opportunity. Despite a shoreline longer than the coasts of Oregon and California combined and annual visitation half as large as Glacier National Park's, the project cannot boast one all weather road leading to the body of the lake. Without question, improved access would increase visitor use, but problems of cost have yet to be resolved. Access to the three areas favored by State and local authorities must cope with long distances (in excess of

20 miles), soils with poor trafficability, and local scarcity of good gravel. The total estimated cost of eight to twelve million dollars for all three roads puts them outside the capability of State or local financing. Although Public Law 93-643, the Federal Aid Highway Amendment of 1974, provides for 70% Federal cost sharing in the construction of access highway to certain lake shore public recreation areas, funding has been limited and the priority of Fort Peck recreation areas has been too low to result in a solution to the problem.

158. Future efforts must be based on identification of those areas with the greatest recreational potential and establishment of priorities for their development. The most appropriate vehicle for accomplishing this seems to be the Fort Peck Master Plan, which is scheduled for updating in FY 1978. The update will include an assessment of the entire project's long-term potential as a public recreation resource and of its ability to meet specific long and short-term public needs. Access will be addressed as one of these specific needs. A separate report to Congress will be prepared if the update effort shows it to be warranted; it would contain documentation to support funding recommendations. Since this established procedure is available, no further action is proposed in this report.

Selecting a Plan

159. Federal agencies within the Executive Branch are obligated to conform, to the fullest extent appropriate, with the Principles and Standards for Planning Water and Related Land Resources, 38 FR

24778-24869, 10 September 1973, as implemented for the Corps of Engineers by the 10 November 1975 publication of the ER 1105-2-200 series. The System of Accounts (SA) is a display presented at the conclusion of this section with the four accounts of National Economic Development (NED), Environmental Quality (EQ), Social Well-Being (SWB) and Regional Development (RD). This display is a specific requirement of the Principles and Standards; it contains information intended to demonstrate the significant adverse and beneficial effects as measured by the yardstick of the four accounts, for each alternative subjected to P&S evaluation. Specified evaluation criteria in Principles and Standards implementation guidance include acceptability, completeness, effectiveness, efficiency, certainty, geographical scope, NED benefit-cost ratio, reversibility and stability. These parameters are analyzed in appropriate portions of the display.

160. No such obligation rests upon the Legislative Branch to observe Principles and Standards methodology, and to the extent that Congress has bypassed that methodology in enacting water resource legislation it is omitted from full treatment in the System of Accounts. Environmental impacts, however, are assessed for each structural alternative discussed.

161. For each element evaluated in the System of Accounts, one or more numerical entries under the columnar head "Coding" will be found. These comply with specific requirements of ER 1105-2-921 and are defined as follows.

<u>Timing</u>

1. Impact is expected to occur prior to or during implementation of the plan.

2. Impact is expected within 15 years following implementation.

3. Impact is expected in a longer time frame (15 years or more following implementation.

● <u>Uncertainty</u>

4. The uncertainty associated with the impact is 50 percent or more.

5. The uncertainty is between 10 percent and 50 percent.

6. The uncertainty is less than 10 percent.

● <u>Exclusivity</u>

7. Overlapping entry; fully monetized in NED account.

8. Overlapping entry; not fully monetized in NED account.

● <u>Actuality</u>

9. Impact will occur with implementation.

10. Impact will occur only when specific additional actions are carried out during implementation.

11. Impact will not occur because necessary additional actions are lacking.

Bank Stabilization

162. Courses of action in response to the area's bank erosion problems have been reduced to two alternatives with a reasonable prospect of occurrence:

● In the absence of technical input and consequent recommendations in this report, a continuation of the existing situation may be expected. This situation is not, however, one of no Federal action. It consists of Congressional action without the benefit of timely assistance from the Corps of Engineers in the form of advanced establishment of critical areas, priorities of effort and cost estimates. The follow-on to such action is a belated effort by the Corps to remedy these data gaps, a sequence of unnecessary and ill-received delays in placing the works under construction, and an overall increase in project cost.

● Based upon analyses of technical data accomplished during this study, the Corps of Engineers can document the scope of the stabilization job yet undone, distinguish between those portions specifically required by Section 161 and those permitted by Section 32, and recommend an optimal plan to accommodate both elements.

163. To define two such alternatives is to select one. This report does contain study results. It does present recommendations for treatment of the problem areas, recommendations which have received widespread support from agencies of State and local government from eminent environmental interests and from citizens who spoke at public meetings held throughout the area. It must not be forgotten, however, that selection of this alternative is the result of a unique pair of prior conditions which bears repeating here. First, there is no reasonable basis to weigh the selected plan against lack of any Federal action; Federal action has been, is now, and will continue to occur. Secondly, this existing commitment to Federal action renders application of the Principles and Standards irrelevant. The Principles and Standards are a methodology whereby water resource agencies in the Executive Branch formulate water resource plans. This plan has long since been formulated and in part implemented; the point of no return has been passed.

164. The procedure selected by this report in response to the bank erosion problem consists of a recommendation for the following elements:

- Design and construction of works at Missouri River sites specifically identified and authorized by Section 161, PL 94-578.
- Design and construction of works at sites authorized by river reach below Garrison, **Fort Randall, and Gavins Point Dams in Section 32, PL 93-251 and identified in this report.**
- Design and construction of works at sites identified in this report in the reach below Fort Peck Dam **(at five locations)** and in the reach below Oahe Dam (at one location).

165. As one of the major water courses on the North American continent, the Missouri River will not be restrained by a single structural effort and subsequent neglect. No matter how soundly designed, bank stabilization will require follow-on maintenance. The Streambank and Erosion Control Evaluation and Demonstration Act of 1974 called

for local sponsorship of all works accomplished thereunder; if it is to serve as an adjunct to that Act this report must be consistent with it. The very magnitude of the undertaking does, however, call for a down-to-earth appraisal of the assumption of maintenance responsibility. No local agencies within the study area possess the resources to maintain a project while it is in the "evaluation" phase. Only when project works have reached a condition of evident stability will it be realistic to transfer responsibility to local sponsors. Understandings toward this end have been reached in obtaining sponsorship for work on the seven sites in the Garrison reach under PL 88-253, where a three-year "seasoning period" after completion will precede local assumption of maintenance responsibility. In similar fashion, all Section 32 projects will be under Federal maintenance throughout a "demonstration period" up to five years long, after which the project will be rehabilitated as necessary before turning it over for local maintenance. A compatible approach is proposed in this report.

Hydro-Power

166. An environmental quality (EQ) plan element addressed to electrical generation appears obscure at best. Designated EQ plan elements must satisfy rigid requirements which conflict with the planning objective of fulfilling future energy demands. Moreover, the option of "No Federal Action" does not resolve the dilemma since our present national response would be to meet the demand by private means. The non-Federal alternative, if built within Federal and State water and air pollution standards, should not result in significant adverse national environmental quality effects. This does not suffice for qualification as an EQ element, however; net positive environmental effects must be identified. These are lacking in the least-costly, non-Federal alternative, which in this study has been determined to be oil-fired combustion turbines at load centers throughout the region. Consequently, combustion turbines are precluded from designation as an EQ element; however,

they most nearly approach EQ requirements and will be regarded throughout plan evaluation as the EQ oriented NED alternative. Plant locations and some other detailed data are lacking at this juncture.

ADDITIONAL UNITS AT FORT PECK

167. The two remaining concepts for adding to the hydro-power installation at Fort Peck entail putting turbine-generators on the two existing flood control tunnels for a total increase of 185 megawatts installed capacity. One alternative includes a reregulation dam eight miles downstream; the other omits it. The third alternative shown in the display is the non-Federal alternative consisting of an oil-fired combustion turbine. The next four paragraphs summarize effects displayed in the System of Accounts tabular presentation.

168. National Economic Development: (Displayed in Table D-4)

- The cost of the non-Federal alternative serves as a surrogate estimate of benefits for the hydro-power alternatives. In the current analysis, the non-Federal alternative is presumed to provide benefits equal to the associated costs resulting in a benefit-cost ratio of 1.0. (Plan A)

- The plan which shows the greatest net benefits is the two-unit 185 megawatt alternative without a reregulation structure. This alternative is the designated NED plan with net benefits of $3,119,000 and a benefit-cost ratio of 1.7. (Plan C)

- The alternative with reregulation, which responds to expressed environmental concerns at an addition of $13,000,000 in capital costs, provides net benefits of $2,301,000 and a benefit-cost ratio of 1.4. (B)

169. Environmental Quality: (Displayed in Table D-5)

- The alternative without reregulation, noted as the NED plan, has incurred significant environmental objections. It would increase the instantaneous peak discharge from Fort Peck by 17,400 cubic feet per second (116%) resulting in fluctuations in the tailwater area some 3.6 feet greater than under existing operating conditions;

eight miles downstream the increase would be 2.8 feet. About 150 acres of terrestrial habitat would be lost in the first 20 miles due to increased river stage fluctuations. Riverine losses would also be experienced in this reach since fish spawning and benthic productivity would be reduced. (C)

Reregulation would minimize fluctuations downstream, concentrating them in the eight-mile reregulation pool. (B) The pool itself would cause some loss, however, inundating 200 acres of existing terrestrial habitat and increasing the potential for the spread of waterfowl disease. On balance, a reregulation structure is preferred by the U. S. Fish and Wildlife Service and concerned state agencies over operation of the additions without reregulation.

The non-Federal alternative (A) of oil-fired combustion turbines would not be expected to exceed current State and Federal air quality standards. Air quality parameters of relevance are particulate content, sulfur dioxide, and nitrogen dioxides. Based upon the performance of similar units already designed, particulare content of emissions would be of minimal concern; any one of the several turbine installations could be expected to increase existing annual peak-day concentrations by about a percent and annual average concentrations by less than one-hundredth of that amount. The annual and average increments by which SO_2 would contribute to allowable limits under Federal air quality standards approximate three percent for peak-day and 0.3 percent for annual average loadings. The impact which emissions of nitrogen oxides would have on local and regional photochemical oxidant concentrations is currently unknown.

170. Social Well-Being: (Displayed in Table D-6)

Common to all three alternatives would be a positive contribution in meeting the growing power needs of the region, thereby maintaining or raising employment productivity and the resultant standard of living.

Over the long term a somewhat higher fraction of long-term income would be required to obtain a given amount of power under the non-Federal alternative, since it is less cost-effective than either Federal alternative. In addition to the greater production cost per KWH, this type of facility consumes scarce non-renewable fossil fuels, the movement of which to a plant site would place additional requirements on the existing transportation system. Construction employment is estimated at 50 persons; because peaking turbines are customarily located at or near a major metropolitan load center, demands for housing and community services during the construction period would be met with less stress than under either of the remaining alternatives.

● Effects of hydro-power alternative B or C during construction would be localized and would relate primarily to construction worker demand for housing and community services. The peak employment requirements for the hydro-power alternatives with and without reregulation are estimated at 350 and 300 workers, respectively. Such an influx could be somewhat burdensome on the small communities near the construction site.

171. Regional Development: (Displayed in Table D-7)

● Net benefits shown in the display correspond to net benefits for the nation. Since consumers in the power marketing region repay the Federal hydro-power investment and operating costs, and the annual benefits are based on the annual costs of the least costly alternatives, this estimate of regional benefits is appropriate. Also included are the regional benefits for employment of unemployed resources. Additional effects relate to local and regional markets for goods and services, particularly housing, a scarce resource. Housing construction activities will be induced with concurrent pressure on housing prices during the construction of power alternatives. This phenomenon will be more significant for hydro-power alternatives B and C because temporary increases in population will be larger both absolutely and relatively in the smaller communities serving the construction area than near the metropolitan sites of oil-fired combustion turbine units. (A)

172. Selection: Addition at Fort Peck of two units with installed capacity of 185 megawatts and a reregulation structure approximately eight miles downstream (Plan B) was chosen on the basis of the following criteria of primary significance:

- Although Plan B is less efficient in maximizing net benefits than is the plan without reregulation (Plan C), it still exceeds by half the efficiency of the non-Federal alternative (Plan A).
- Both Plan B and Plan C result in environmental impacts of greater geographic scope than does Plan A. Adverse effects of Plan C extend downstream perhaps twenty miles while those of Plan B are confined to the eight-mile reach of the reregulation reservoir, below which conditions will be improved over those existing prior to addition of the two units.
- Plan B is more acceptable in the eyes of State and national environmental interests than is Plan C. Plan B is more acceptable from the viewpoint of regional energy production and national energy policy than is Plan A.

ADDITIONAL UNITS AT GARRISON

173. In common with Fort Peck, the alternatives retained for final consideration at Garrison consist of additional turbine-generator units with and without reregulation (Plans B and C) and a combustion fired oil turbine (Plan A) to be expected in the absence of either Federal action. Three flood control tunnels are available for use in the Garrison expansion, compared to two at Fort Peck, and the installed capacity is correspondingly larger, with an increased 272 megawatts. A comparison of effects under the three plans is displayed in the System of Accounts tables at the conclusion of this summary.

174. National Econonic Development: (Displayed in Table D-8)

- As usual, annual power benefits are based on the annual

TABLE D-4 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT FORT PECK DAM

NATIONAL ECONOMIC DEVELOPMENT

	Coding 1/	Non-Federal Alternative: Plan A 2/ Combustion Turbine	Turbine-Generators Added at 2 Flood Control Tunnels: Plan B with Reregulation	Plan C 3/ without Reregulation
		BENEFICIAL IMPACTS IN $1,000		
Power	1,6,9	7,799	7,799	7,799
Area Redevelopment	1,5,9	0	110	90
TOTAL BENEFICIAL IMPACTS		7,799	7,909	7,889
		ADVERSE IMPACTS IN $1,000		
Investment Cost	1,6,9		84,253	71,100
Interest and Amortization	1,6,9		5,382	4,542
Operation, Maintenance and Replacement (OM&R)	1,5,9		203	196
Recreation Loss	1,5,9		23	32
TOTAL ADVERSE IMPACTS		7,799	5,608	4,770
		NED PERFORMANCE		
Net NED Benefits		0	$2,301,000	$3,119,000
Benefit/Cost Ratio		1.0	1.4	1.7

1/ See Par. 161

2/ EQ Oriented Plan

3/ NED Plan

TABLE D-5 SYSTEM OF ACCOUNTS ADDITIONAL HYDRO-POWER AT FORT PECK DAM

ENVIRONMENTAL QUALITY

	Coding [1/]	Non-Federal Alternative: Plan A [2/] Combustion Turbine	Turbine-Generators Added at 2 Flood Control Tunnels: Plan B With Reregulation	Turbine-Generators Added at 2 Flood Control Tunnels: Plan C [3/] Without Reregulation
Biological Parameters				
Habitat				
Aquatic	2,6,9	Nor Applicable	Decreased river stage fluctuations downstream from rereg dam. Increased temperature stability downstream from rereg dam. Because of stage stabilization some tidal areas will vegetate, increasing their habitat value. Approx 44% net aquatic habitat degradation in dredge cut area with appropriate mitigative measures to maintain constant water levels. Approx 90% habitat degradation of 8 mi of river. Changes in habitat type within the freeboard zone will not result in significant changes in net habitat values.	Increased river stage fluctuations downstream from Ft Peck Dam. Decreased temperature stability downstream from Ft Peck Dam. Area of water surface will decrease significantly at low stages. Increased stage fluctuations will result in increased tidal areas. This may benefit some shore birds but will result in habitat value reduction. Reduction in river habitat value for 20 mi below Ft Peck Dam due to increased stage and current fluctuations. Water surface area will show drastic reductions at low stages.
Terrestrial	2,6,9	Destruction of 10 acres of terrestrial habitat at construction site. Vegetation will be degraded within the area adjacent to the plant site. 4/	Loss of approx 200 acres of terrestrial habitat within rereg pool. Some land areas in rereg pool will be lost due to erosion and bank slope adjustment. Groundwater regimes will be altered on islands and for an undetermined distance from the bank, resulting in some vegetational changes. This possibility exists for approx 700 acres of freeboard zone surrounding rereg pool. Protection of island land in the freeboard zone and above and acquisition of about 480 acres of woodland and shrub grassland would mitigate the terrestrial habitat losses.	Loss of approx 150 acres of terrestrial habitat bordering the river due to a one-time bank slope adjustment. This will occur sporatically for a distance of 20 mi downstream from Ft Peck Dam. Groundwater regimes will be altered on islands for an undetermined distance from the bank, resulting in minor habitat changes near the river. Periodic inundation will degrade approx 200 acres of terrestrial habitat, 150 acres of bankline, and 50 acres of island. Terrestrial vegetation occupying this area will be lost. About 900 acres of predominantly savanah and hardwood forests would be acquired to mitigate these losses.
Biota				
Mammals	2,6,9	Construction and operations will result in the loss of some small mammals from the plant site and adjacent areas. 4/	Loss of some small mammals within the rereg pool area. Populations of beaver and muskrat will show significant decreases in the rereg pool area. Deer populations may show a slight decrease.	Populations of terrestrial annimals such as deer, voles, etc., will show slight decreases. Populations of beaver, muskrat, etc., will show significant decreases.
Birds	2,6,9	Degraded air quality, noise and construction will repel some bird species from the plant area and adjacent areas. Landscaping may attract some species such as robins, etc.	Some avian habitat will be destroyed by inundation within rereg pool. Some destruction of Canada goose nesting sites the US F&WL established on Duck and Scout Islands. These sites presently produce about 40 goslings a year. Lands for compensation of goose nesting habitat should keep a significant portion of current production in existence.	Increased potential for waterfowl diseases due to "short-stopping" of migratory flights. Some sandbar nesting sites will be destroyed in tidal area. Some destruction of Canada goose nesting sites which US F&WL has established on Duck and Scout Islands. Goslings may not be able to survive in this fluctuating habitat. Present production of goslings in this area is approx 40 per year.
Fish	2,6,9	Not Applicable.	Rereg dam will block upstream fish migration into Ft Peck tailrace and dredge cuts. Fish population will be eliminated in rereg pool, however, dredge cut area will be protected thus showing no significant losses. Paddlefish will no longer be seasonally abundant in dredge cut area. A fishery similar to that existing below Ft Peck Dam will develop below rereg dam. The fishery in dredge cut area may have to be managed. Decreased stage and current velocity fluctuations will result in slightly improved fish habitat below rereg dam. Increased relative abundance in fish species below the rereg dam.	Decreases in relative abundance of tailrace fish species. The dredge cuts will be protected showing no significant losses. Decreases in overall fish abundance will result from stranding in temporary pools due to ruver stage decreases.
Insects	2,6,9	Minor negative effect on insect populations. 4/	Over 90% decrease in benthos quantity and diversity in rereg pool. Terrestrial insects in the area to be inundated will be eliminated. Due to vegetation of some tidal area insect populations should show slight increases. Slight increase in insect populations in the stabilized downstream reaches.	Decreased abundance in aquatic insects due to river stage and current velocity fluctuations for approximately 20 mi downstream from Ft Peck dam with the most significant decreases in the upper 5-mile reach. Insect populations in the dredge cut area will not be affected.
Pollution Parameters				
Water	1,6,9	No measurable effect on water quality, barring oil spills or leakage.	Temporary turbidity increase due to construction and erosion in the rereg pool. This turbidity could be of several years duration, diminishing with time.	Temporary turbidity increase due to erosional one-time bank slope adjustment. This turbidity may be less than one year in duration.
Air	2,6,9	Increased quantities of SO_2, NO_2, CO_2, CO and particulate matter. Expected to stay within EPA limits.	Not Applicable	Not Applicable
Noise	2,6,9	Increased noise pollution, expected to stay within EPA limits.	Not Significant	Not Significant

1/ See Par. 161
2/ EQ Oriented Plan
3/ NED Plan
4/ Impact will occur with initiation of construction.

TABLE D-6 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT FORT PECK DAM

SOCIAL WELL-BEING

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Turbine-Generators Added at 2 Flood Control Tunnels Plan B With Reregulation	Plan C 3/ Without Reregulation
Health and Safety	2,6,9	Operation emits gaseous and particulate matter within air quality standards. Effects of nitrogen dioxide, a major by-product, unknown.	No degradation of air or water quality.	Same as Plan B
Community Well Being	2,6,9	No. 2 distillate fuel oil competes with other uses, i.e. home heating.	Operations do not consume water or other resources	Same as Plan B.
	2,6,9	Fuel oil prices subject to foreign influence.	Prices dependent on national water resource management policies.	Same as Plan B.
	1,6,9	National goal of energy self-sufficiency not served by expanded use of imported fuel.	National goal of energy self-sufficiency enhanced.	Same as Plan B.
Community Cohesion	1,6,9	Construction likely to occur in metropolitan areas where sufficient labor is available.	Supplemental skilled and common labor must be recruited beyond commuting area. Construction workers and families may place some stress on local community services and facilities.	Same as Plan B.
	1,6,9	Additional requirements placed on transportation system to move fuel to plant site.	No significant effect.	Same as Plan B.
	1,5,9	Site requires 50-100 acres.	Land acquired, 1290 acres for reregulation pool and 480 acres for wildlife mitigation will be unavailable for other uses.	Approximately 900 acres acquired for wildlife mitigation will be unavailable for other uses.
Desirable Community Growth	1,6,9	Small percentage increase in metropolitan area economy and resultant demand for community services.	Rural retail and service activities stimulated by construction. Need 4 new or refurbished housing units for permanent personnel and families. Profitability of local businesses and efficiency of community services and facilities enhanced.	Same as Plan B.
Recreation Opportunities	2,6,9	Plant site removed from any possible recreation use.	Drastic daily fluctuations in pool elevation and river stage will greatly reduce recreation opportunities inside the 8-mile reregulation pool.	Drastic daily fluctuations in stage greatly reduce recreation opportunities immediately below dam, decreasing to negligible effect 20 miles downstream.
Aesthetic Values	2,6,9	Little impact in industrial areas.	Reregulation structure and pool replace a riverine environment with an artificial structure where large sand bars are created daily.	Low flows occur daily creating sand bars below dam. Effects diminish downstream, becoming negligible within 20 miles.

1/ See Par. 161
2/ EQ Oriented Plan
3/ NED Plan

TABLE D-7 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT FORT PECK DAM

REGIONAL DEVELOPMENT

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Turbine-Generators Added at 2 Flood-Control Tunnels Plan B With Reregulation	Plan C 3/ Without Reregulation
Net Benefits				
Power Marketing Region	1,6,9		$2,301,000	$3,119,000
Rest of Nation	1,6,9		0	0
Total			$2,301,000	$3,119,000
Study Area Employment				
Peak Construction	1,5,9	50	350	300
Operation and Maint.	2,5,9	10	4	4
Property Values	1,6,9	Value of land and improvements not affected in metropolitan Area.	Value of housing temporarily inflated in nearby communities.	Same as 2 units with reregulation.
Property Tax Revenues	1,5,9	Tax Revenue on powerplant: $382,000	$5,500 lost per year in taxes on agricultural land.	Approximately $3,000 lost per year in taxes on agricultural land.
Income Loss	1,5,9		$74,000 lost per year from agricultural land use.	$38,000 lost per year from agricultural income.

1/ See Para. 161

2/ EQ Oriented Plan

3/ NED Plan

cost of Plan A.

- Plan C maximizes net benefits at $4,791,000 per year with a benefit to cost ratio of 2.0 to 1.

- Plan B, which minimizes the effects of hydro-power generation on the river downstream of the reregulation pool has net benefits of $3,534,000 with a benefit to cost ratio of 1.6 to 1.

175. Environmental Quality: (Displayed in Table D-9)

- Plan C increases full-gate discharge from the power plant by about 30,000 cfs. Typical stage fluctuation in the tailwater area will increase from the present 11 feet to 16 feet; thirty miles downstream, typical present and future fluctuations are four feet and five feet. Another measure of the effects of power peaking on the riverine habitat is the change in water surface. To evaluate this parameter with some degree of confidence, a special operation was conducted wherein Garrison discharges were held to zero for 16 hours. Two sets of aerial photographs were taken, along with stage readings at a number of river gages. The photographs indicate that ten miles below the dam maximum reduction in water surface of about 30 percent occurred when releases fell from 30,000 cfs to zero. Thirty miles below the dam, the reduction in water surface was 15 percent. These data do not, by themselves, tell the entire story of environmental effects, but they do serve as convenient indicators for use in documenting the decision-making process. A full discussion of project effects of the selected plan is contained in Section E.

- Plan B includes a reregulation reservoir approximately 10 miles long within which daily pool fluctuations up to 14 feet will occur. Downstream, the minimum instantaneous release would never fall below 60 percent of the daily average, thereby providing more uniform flows than are found under present conditions. This plan would require some remedial works to insure unrestricted future operation of the Garrison fish hatchery. About one-quarter of a mile downstream of the fish hatchery is a Federally-owned tract of

1,460 acres known as the Riverdale Game Management Area and operated by the state of North Dakota. Bisecting this tract is a swale leading from the river, with about 120 acres lying between elevation 1682 (maximum water surface in the reregulation pool) and elevation 1685. The North Dakota Game and Fish Department has expressed concern that the water table will stabilize at the maximum elevation of 1682, leaving eight percent of the tract with groundwater three feet or less below the surface and changing the existing plant community. The Bismarck area office of the U. S. Fish and Wildlife Service supports this concern; as a result both agencies have voiced total opposition to the reregulation concept. This does not imply their preference for Plan C; to the extent their influence prevails, the input from both agencies to the study effort has been abandonment of any hydro-power additions at Garrison. It should be noted that assuming the water table to stabilize at 1682 is a limiting condition - an unrealistic case nearly impossible to realize. Transmissivity tests to enable accurate predictions of ground water behavior in response to fluctuating pool elevations have not yet been made but are proposed during advanced design studies.

- The effects of Plan A would correspond to those of Plan A at Fort Peck.

176. Social Well-Being: (Displayed in Table D-10)

- All three alternatives help to meet the region's power needs.
- Plan A effects correspond to those identified in paragraph 170 as occurring at Fort Peck.
- Plan B and C effects in general also correspond to those shown in paragraph 170. Differences in quantification are identified in Table D-10.
- In addition, Plan B results in less detriment to recreation than does Plan C. Along the Missouri downstream of Garrison Dam, either Plan B or C will probably stimulate sightseeing. However, participative activities such as fishing, boating and swimming will be in large measure eliminated in the 20 miles immediately downstream

of the dam under Plan C. Under Plan B a high percentage of this activity is expected to survive - merely shifting locale downstream of the reregulation dam. Participative activities are estimated to generate about two-thirds of the present visitation in the river downstream of Garrison, which has been ranging from 120,00 to 190,000 per year.

177. Regional Development: (Displayed in Table D-11)

● Regional impacts of the three plans at Garrison do not differ significantly from those discussed in paragraph 171 as being applicable at Fort Peck.

178. Selection: Addition at Garrison of three units with installed capacity of 272 megawatts with reregulation (Plan B) was chosen on the basis of the following criteria of primary significance:

● Plan C, the NED plan, is the most cost effective; however, compared to Plan A, both Plan B and Plan C provide substantial net benefits.

● Both Plan B and Plan C result in environmental effects of greater geographic extent than Plan A. Adverse effects of Plan C extend about 30 miles below Garrison Dam while those of Plan B are confined to the vicinity of the 10-mile reregulation pool. Plan B will result in improved environmental conditions throughout the remainder of the reach below the reregulation dam.

● Plan C will reduce social well-being by largely eliminating substantial recreation opportunities below the dam. With Plan B, recreation opportunities will be essentially preserved by merely shifting to a new location downstream of the reregulation structure.

● Plan B and Plan C are more acceptable from a regional energy production and national energy policy viewpoint than Plan A.

● Based on the above considerations and the comments received during field level review of the alternative plans, Plan B was selected as a reasonable trade between a decrease in net economic benefits, environmental quality, and areal extent when compared to

Plan C.

GREGORY COUNTY PUMPED-STORAGE HYDRO-POWER

179. Only two meaningful alternatives remain for consideration at Gregory County: Federal construction of a pumped-storage hydro-power plant or non-Federal fulfillment of the peaking demand by construction of the most likely alternative source of generation. Within the Federal project there does exist the further option noted in paragraph 151, of providing a multiple-purpose project providing municipal, rural domestic and even agricultural water supply as well as 1180 mw of peaking power.

180. The opportunity for multiple-purpose use of the project lies in the large capacity of the units in the pumping mode, when they can deliver 16,500 cubic feet per second; the number of hours per week committed neither to pumping nor to generation - 55.5; and the availability of moderately priced energy during a portion of that 55.5 hours. Under these circumstances the water required to irrigate 10,000 acres could be raised from Lake Francis Case to the Gregory County forebay, by operating the pumps for a maximum additional duration of an hour and a half per week. The municipal requirements of a community of 1,000 people could be met by running the pump one additional second per day.

181. Obviously, the Gregory County facility has the physical ability to serve as a source of municipal and even agricultural water supply in the high plains area of Gregory County. In response to numerous local and Congressional inquiries the Corps of Engineers has emphasized that economic costs have just begun when water is delivered to the forebay. Distribution for any use and treatment for municipal use may prove to be the major components of total cost; these areas lie outside the authorities of the Corps.

TABLE D-8 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT GARRISON DAM

NATIONAL ECONOMIC DEVELOPMENT

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Turbine-Generators Added at 3 Flood Control Tunnels Plan B with Reregulation	Plan C 3/ without Reregulation
		BENEFICIAL IMPACTS IN $1,000		
Power	1,6,9	9,489	9,489	9,489
Area Redevelopment	1,5,9	0	115	90
TOTAL BENEFICIAL IMPACTS		9,489	9,604	9,579
		ADVERSE IMPACTS IN $1,000		
Investment Cost	1,6,9		90,748	70,099
Interest and Amortization	1,6,9		5,797	4,478
Operation, Maintenance and Replacement (OM&R)	1,5,9		241	230
Recreation Loss			32	80
TOTAL ADVERSE IMPACTS		9,489	6,070	4,788
		NED PERFORMANCE		
Net NED Benefits		0	$3,534,000	$4,791,000
Benefit/Cost Ratio		1.0	1.6	2.0

1/ See Par. 161

2/ EQ Oriented Plan

3/ NED Plan

TABLE D-9 SYSTEM OF ACCOUNTS ADDITIONAL HYDRO-POWER AT GARRISON DAM

ENVIRONMENTAL QUALITY

	Coding 1/	Non-Federal Alternative: Plan A 2/ Combustion Turbine	Turbine-Generators Added at 3 Flood Control Tunnels: Plan B With Reregulation	Plan C 3/ Without Reregulation
Biological Parameters				
Habitat: Aquatic	2,6,9	Not Applicable	Decreased river stage fluctuation downstream from the rereg dam. Increased temperature stability downstream from the rereg dam. Because of stage stabilization some tidal areas will vegetate, increasing their habitat value. Approx 90% degradation of 10 mi of river in the rereg pool reach. The "Pike Hole" area located approximately 2.5 mi downstream from Garrison dam will show a 90% habitat degradation due to stage fluctuations. Changes in habitat type within the freeboard zone will not result in significant changes of net habitat values.	Increased river stage fluctuations downstream from Garrison dam. Decreased temperature stability downstream from Garrison Dam. Area of water surface will decrease significantly at low stages. Increased stage fluctuations will result in increased tidal areas. This may benefit some shore birds but will result in a habitat value reduction. Reduction in river habitat value for 30 mi below Garrison dam due to increased stage and current fluctuations. The "Pike Hole" area located approx 2.5 miles downstream from Garrison dam will show a 90% habitat degradation due to stage fluctuations. Water surface area will show drastic reductions at low stages.
Terrestrial	2,6,9	Destruction of 10 acres of habitat at construction site. Vegetation will be degraded within the area adjacent to the plant site. 4/	Loss of approx 180 acres of terrestrial habitat due to rereg pool inundation. Approx 270 acres of similar habitat will be purchased to mitigate this loss. Groundwater regimes will be altered on island and for an undetermined distance from the bank resulting in some vegetational changes, causing no net habitat value loss. This possibility exists for approx 1200 acres of freeboard zone surrounding the rereg pool. The Riverdale State Game Management Area will suffer some detrimental effects due to rereg pool fluctuations. Approx 43% of this area will have the potential to show vegetative changes because of altered groundwater regimes or inundation.	Loss of approx 190 acres of terrestrial habitat bordering the river due to a one-time bank slope adjustment. This loss will be mitigated by the acquisition of 285 acres of similar habitat. For a distance of 30 mi downstream, peaking effects will periodically inundate approx 190 acres of low bank area. Groundwater regimes will be altered on islands and for an undetermined distance from the bank, resulting in minor habitat changes near the river. The Riverdale State Game Management area will suffer some detrimental effects due to increased river stages. Approx 43% of this area will have the potential to show vegetative changes because of altered groundwater regimes.
Biota: Mammals	2,6,9	Construction and Operations will result in the loss of some small mammals from the plant site and adjacent area. 4/	Loss of some small mammals within the rereg pool area. Populations of beaver and muskrat will show significant decreases in the rereg pool area. Deer populations may show slight decreases.	Populations of terrestrial animals such as deer, voles, etc., will show slight decreases. Populations of beaver, muskrat, etc., will show significant decreases.
Birds	2,6,9	Degraded air quality, noise and construction will repel some bird species from the plant area and adjacent areas. Landscaping may attract some species such as robins, etc.	Some avian habitat will be destroyed by inundation. Increased potential for waterfowl diseases due to "short-stopping" of migratory flights.	Increased potential for waterfowl diseases due to "short-stopping" of migratory flights. Some sandbar nesting sites will be destroyed in the tidal area.
Fish	2,6,9	Not Applicable	Rereg dam will block upstream fish migrations into the tailrace area. Fish populations will be eliminated in the rereg pool. A fishery similar to that existing below Garrison dam will develop below the rereg dam. Any spawning areas within the rereg pool will be eliminated. River stage increases will result in decreased usability of Garrison National Fish Hatchery. This problem can be alleviated by mitigative efforts. Decreased stage and current velocity fluctuations will result in slightly improved fish habitat below the rereg dam. Increased relative abundance of fish species below the rereg dam. Garrison National Fish Hatchery will be modified to remain operational.	Decreases in relative abundance of tailrace fish species. Any existing spawning sites 20 mi downstream from Garrison dam will be severely degraded. River stage fluctuations may eliminate upstream tributary migrations. River stage increases will result in decreased usability of the Garrison National Fish Hatchery. This problem can be alleviated by mitigative efforts. Decreases in overall fish abundance will result from stranding in temporary pools due to stage fluctuations. Lower river stages at tributary mouths may restrict upstream tributary migrations. Garrison National Fish Hatchery will be modified to remain operational.
Insects	2,6,9	Minor negative effect on insect habitat and populations. 4/	Over 90% decrease in benthos quantity and diversity in the rereg pool. Terrestrial insects in the area to be inundated will be eliminated. Due to vegetation of some tidal areas insect populations should show slight increases. Slight increase in insect populations in the stabilized downstream reaches.	Decreased abundance in aquatic insects due to river stage and current velocity fluctuations for approx 30 mi downstream from Garrison dam with the most significant decreases in the upper 5-mile reach.
Pollution Parameters				
Water	1,6,9	No measurable effect on water quality, barring oil spills or leakage.	Temporary turbidity increase due to construction and erosion in the rereg pool. This turbidity could be of several years duration, diminishing with time.	Temporary turbidity increase due to erosional one-time bank slope adjustment. This turbidity may be less than one year in duration.
Air	2,6,9	Increased quantities of SO_2, NO_2, CO_2, CO and particulate matter. Expected to stay within EPA limits.	Not Applicable	Not Applicable
Noise	2,6,9	Increased noise pollution, expected to stay within EPA limits.	Not Significant	Not Significant

1/ See Par.161
2/ EQ Oriented Plan
3/ NED Plan
4/ Impact will occur with initiation of construction.

TABLE D-10 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT GARRISON DAM

SOCIAL WELL-BEING

		Non-Federal Alternative	Turbine-Generators Added at 3 Flood Control Tunnels	
	Coding 1/	Plan A 2/ Combustion Turbine	Plan B With Reregulation	Plan C 3/ Without Reregulation
Health and Safety	2,6,9	Operation emits gaseous and particulate matter within air quality standards. Effects of nitrogen dioxide, a major by-product, unknown	No degradation of air or water quality.	Same as Plan B
Community Well Being	2,6,9	No. 2 distillate fuel oil competes with other uses; i.e., home heating.	Operations do not consume water or other resources.	Same as Plan B
	2,6,9	Possible noxious odors and noise in area	No increase of odor or noise in area	Same as Plan B
	2,6,9	Fuel oil prices subject to foreign influence.	Prices dependent on national water resource management policies.	Same as Plan B
	1,6,9	National goal of energy self-sufficiency not served by expanded use of imported fuel.	National goal of energy self-sufficiency enhanced.	Same as Plan B
Community Cohesion	1,6,9	Construction likely to occur in metropolitan areas where sufficient labor is available.	Supplemental skilled and common labor required beyond commuting area. Construction workers and families may place some stress on local community services and facilities.	Same as Plan B
	1,6,9	Additional requirements placed on transportation system to move fuel to plant site.	No significant effect.	Same as Plan B
	1,5,9	Site requires 50-100 acres.	Land acquired 2305 acres for rereg pool and 270 acres for wildlife mitigation, will be unavailable for any other uses.	Approx 285 acres acquired for wildlife mitigation unavailable for any other uses.
Desirable Community Growth	1,6,9	Small percentage increase in metropolitan area economy and resultant demand for community services.	Rural retail and service activities stimulated by construction. Need 5 new or refurbished housing units for permanent personnel and families. Profitability of local businesses and efficiency of community services and facilities enhanced.	Same as Plan B
Recreation Opportunities	2,6,9	Plant site removed from any possible recreation use.	Drastic daily fluctuations in pool elevation and river stage will greatly reduce recreation opportunities in the 10 miles of rereg pool area.	Drastic daily fluctuations in stage greatly reduce recreation opportunities immediately below dam, decreasing to negligible effect 30 miles downstream.
Aesthetic Values	2,6,9	Little impact on industrial areas.	Rereg structure and pool replace a riverine environment with an artificial structure where large sand bars are created daily.	Daily occurring low flows create sandbars below dam, decreasing to negligible effect 30 miles downstream.

1/ See Par. 161
2/ EQ Oriented
3/ NED Plan

TABLE D-11 SYSTEM OF ACCOUNTS
ADDITIONAL HYDRO-POWER AT GARRISON DAM

REGIONAL DEVELOPMENT

		Non-Federal Alternative	Turbine-Generators Added at 3 Flood-Control Tunnels	
	Coding 1/	Plan A 2/ Combustion Turbine	Plan B With Reregulation	Plan C 3/ Without Reregulation
Net Benefits				
Power Marketing	1,6,9		$3,534,000	$4,791,000
Rest of Nation	1,6,9		0	0
Total			$3,534,000	$4,791,000
Study Area Employment				
Peak Construction	1,5,9	50	380	290
Operation and Maint.	2,5,9	10	5	5
Property Values	1,6,9	Value of land and improvements not affected in metropolitan area.	Value of housing temporarily inflated in nearby communities.	Same as Plan B
Property Tax Revenues	1,5,9	Tax yield from powerplant: $530,000	$11,000 lost per year in taxes on agricultural land.	Approximately $1,200 lost per year in taxes on agricultural land.
Income Loss	1,5,9		$74,000 income lost per year from agricultural land use.	Approximately $8,000 income lost per year from agricultural land use.

1/ See Para. 161

2/ EQ Oriented

3/ NED Plan

182. Although local interests have been informed of the coordination they must undertake with other Federal agencies or with private consulting firms to determine such items as soil suitability for irrigation, distribution and treatment costs, the time available to them prior to completion of this report has proven to be insufficient. Fortunately, addition or deletion of water supply has virtually no effect on the physical configuration of the Gregory project. As a result, this report analyzes the single purpose power project, acknowledges the interest in adding another purpose, and defers detailed design and economic analysis of such firm proposals as may evolve to the Phase I Design Memorandum.

183. National Economic Development: (Displayed in Table D-12)

● A pumped-storage hydro-plant (Plan B) shows net benefits of $17,435,000 a year over the non-Federal alternative (Plan A) consisting of 1,180 megawatts of oil-fired combustion turbine generation.

● When generating 1,000 hours per year, Plan B has a benefit to cost ratio of 1.5 to 1.

184. Environmental Quality: (Displayed in Table D-13)

● Although Plan A is designated as the EQ Oriented NED plan, it shows dubious environmental advantage over Plan B, for which only two substantive environmental impacts have been suggested, both of which are highly speculative.

● It has been suggested that power plant discharges, entering Lake Francis Case may create turbidity, particularly if they should re-suspend the fine colloidal sediment deposited by the White River which joins the Missouri some 43 miles upstream. Definitive analysis of this possibility must await sophisticated modeling studies during Phase I design.

● It has been suggested that unless fish screens are installed, unacceptable mortality to fry will occur. This possibility, too, must await evaluation in Phase I design.

185. Social Well-Being: (Displayed in Table D-14)

- Both alternatives help to meet regional power needs.
- The effects of Plan A are diffused among a number of load centers, since 1,180 megawatts of combustion-turbine generation could not efficiently be located at one site.
- Plan B requires the conversion of about two sections of land from agricultural production to forebay storage with accompanying relocation of seven farm families.
- Construction employment under Plan B will cover a four year period. The peak is expected to exceed 1,000 people, placing a significant demand for housing and community services on a region where no communities lie within a ten-mile radius of the project, six communities ranging in size from 100 to 1,800 are within twenty miles and three additional communities between 100 and 1,000 in size are located within thirty miles.
- Addition of 50 permanent jobs will make a significant contribution to community cohesion and help to reduce the social costs of population dispersion.

186. Regional Development: (Displayed in Table D-15)

- Impacts are similar in nature to those at Fort Peck as discussed in paragraph 171. However, they will be substantially greater because of the much larger expenditures involved.
- Of particular regional significance is the utilization of unemployed resources, estimated at $350,000.

187. Selection: Construction at river mile 918 of the Gregory County pumped-storage hydroelectric peaking plant consisting of three units with total installed capacity of 1,180 megawatts (Plan B) was chosen on the basis of the following criteria of primary significance.

- It offers a more cost effective response to the region's need for added peaking capacity than does Plan A.
- It has the most wide-spread acceptability of the three

hydro-plants selected.

● Expressed environment concerns are few and even they are uncertain to occur.

Recreation, Fish and Wildlife

188. Alternatives retained for final consideration address three areas of opportunity: selection of ways to restore trophy fishing at Lakes Oahe and Francis Case, facilitating recreational access and use of all open river reaches, and consideration of National Wild and Scenic River designation of the Gavins Point-Ponca State Park reach.

TROPHY FISHING

189. Two alternatives remain to meet the objective of restoring the northern pike fishery resource at Lakes Oahe and Francis Case. Both plans consist of two separate actions. The first action, common to both alternatives, is the establishment of semi-aquatic vegetation on 200 acres of denuded lakeshore at each of 12 sites. Seven sites at Oahe and five sites at Francis Case would be seeded and sprigged by conventional farming methods during annual low water and subsequently flooded by rising reservoir pool levels in the spring to establish a forage base for fish species.

190. The second part of both plans will result in the production and release of approximately five million fingerling northern pike annually. Plan A consists of constructing 12 9-acre rearing ponds adjacent to the lakes - seven at Lake Oahe, five at Lake Francis Case. To establish and maintain a viable northern pike fishery it will be necessary to stock the lakes annually. Egg collection will begin during March through April and fertilized eggs placed in egg jars in mobile hatchery trailers. Pike fry will be transferred from the trailers into the rearing ponds and the fingerlings will then be transmitted into the lakes through corrugated metal pipe. Plan B collection and production operations are similar except that

TABLE D-12 SYSTEM OF ACCOUNTS
PUMPED STORAGE HYDRO-POWER—GREGORY COUNTY

NATIONAL ECONOMIC DEVELOPMENT

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Plan B 3/ 3 Pump-Turbine Generator-Motors
		BENEFICIAL IMPACTS IN $1,000	
Power	1,6,9	51,029	51,029
Area Redevelopment	1,5,9	0	350
TOTAL BENEFICIAL IMPACTS		51,029	51,379
		ADVERSE IMPACTS IN $1,000	
Investment Cost	1,6,9		274,553
Interest and Amortization	1,6,9		18,337
Operation, Maintenance and Replacement (OM&R)	1,5,9		1,027
Pumping Cost	1,6,9		14,580
TOTAL ADVERSE IMPACTS		51,029	33,944
		NED PERFORMANCE	
Net NED Benefits		0	17,435,000
Benefit/Cost Ratio		1.0	1.5

1/ See Par. 161

2/ EQ Oriented Plan

3/ NED Plan

TABLE D-13 SYSTEM OF ACCOUNTS
PUMPED STORAGE HYDRO-POWER—GREGORY COUNTY

ENVIRONMENTAL QUALITY

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Plan B 3/ 3 Pump-Turbine Generator-Motors
Biological Parameters			
Habitat			
Aquatic	2,6,9	Not Applicable	This project could provide irrigation and drinking water for some local areas. Degradation of the aquatic habitat might occur locally as a result of increased turbidity due to artificial turbulence. The White River delta, currently located 20 miles upstream, could cause future problems if it moved into the project area without undergoing any consolidation. This could result in increases in iron, manganese and turbidity in the water column. Aquatic vegetation may be degraded due to this increased turbidity. Partial loss of a natural embayment on Lake Francis Case will result due to pumping and discharges facilities.
Terrestrial	2,6,9	Destruction of 20-40 acres of terrestrial habitat at construction site. Vegetation will be degraded within the area adjacent to the plant site. 4/	Approximately 1550 acres of terrestrial habitat of which nearly 100% is agricultural land, will be destroyed due to construction and subsequent inundation. Construction and the construction townsite will temporarily degrade some terrestrial vegetation.
Biota			
Mammals	2,6,9	Construction and operations will result in the loss of some small mammals from the plant site and adjacent areas 4/	These species occupying the 1550 acres of destroyed habitat will be eliminated or displaced.
Birds	2,6,9	Degraded air quality, noise and construction will repel some bird species from the plant area and adjacent areas. Landscaping may attract some species such as robins, etc.	Those species occupying the 1550 acres of destroyed habitat will be displaced.
Fish	2,6,9	Not Applicable	Small amount of mortality due to turbine operations or gilling if screens are installed. During operations, spawning migrations of stream seeking fishes may be diverted. Due to increased turbidity in the area of the pumped storage unit, fish habitat will be degraded or eliminated.
Insects	2,6,9	Minor negative effect on insect habitat and populations 4/	Decreased benthos quantity and diversity due to artificial turbulence, turbidity and disruption of bottom sediments. Terrestrial insects occupying the 1550 acres of destroyed habitat will be eliminated.
Pollution Parameters			
Water	1,6,9	No measurable effect on water quality, barring oil spills or leakage	Some pollution will occur due to the construction townsite. Water quality will be degraded due to increased turbidity and possibly increased iron, manganese concentrations.
Air	2,6,9	Increased quantities of SO_2, NO_2, CO_2, CO, and particulate matter. Expected to stay within EPA limits.	Not Applicable.
Noise	2,6,9	Increased noise pollution, expected to stay within EPA limits.	Not significant

1/ See Par. 16)
2/ EQ Oriented Plan
3/ NED Plan
4/ Impact will occur with initiation of construction

TABLE D-14 SYSTEM OF ACCOUNTS
PUMPED STORAGE HYDRO-POWER—GREGORY COUNTY

SOCIAL WELL-BEING

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Plan B 3/ 3 Pump-Turbine Generator-Motors
Health and Safety	2,6,9	Operation emits gaseous and particulate matter within air quality standards. Effects of nitrogen dioxide, a major byproduct, unknown.	No degradation of air or water quality.
Community Well-Being	2,6,9	No. 2 distillate fuel oil competes with other uses, i.e. home heating.	Operations do not consume water or other resources.
	2,6,9	Possible noxious odors and noise in area.	No increase of odor or noise in area.
	2,6,9	Fuel oil prices subject to foreign influence.	Prices dependent on national water resource management policies.
	1,6,9	National goal of energy self-sufficiency not served by expanded use of imported fuel.	National goal of energy self-sufficiency enhanced.
Community Cohesion	1,6,9	Construction likely to occur in metropolitan areas where sufficient labor is available.	Supplemental skilled and common labor required beyond local commuting area. Need local community facilities, services, and 400 additional housing units for construction workers and families.
	1,6,9	Additional requirements placed on transportation system to move fuel to plant site.	Road network will be upgraded for heavier loads and traffic during construction.
	1,5,9	Site requires 100+ acres.	Headquarters of 7 farms and ranches displaced and 1550 acres removed from agricultural production.
Desirable Community Growth	1,6,9	Little impact on metropolitan area economy or community services.	Rural retail and service activities greatly expanded by construction. Need 50 new or refurbished housing units for permanent personnel and families. Profitability of local businesses and efficiency of community services and facilities enhanced.
Aesthetic Values	2,6,9	Little impact in industrial areas.	Displaces crop and rangeland with manmade seeded embankment 5 to 6 miles long, 25 to 65 feet high. Interior riprapped with stone to level of dead storage pool eliminating mud flats.

1/ See Par. 161

2/ EQ Oriented Plan

3/ NED Plan

TABLE D-15 SYSTEM OF ACCOUNTS
PUMPED STORAGE HYDRO-POWER—GREGORY COUNTY

REGIONAL DEVELOPMENT

	Coding 1/	Non-Federal Alternative Plan A 2/ Combustion Turbine	Plan B 3/ 3 Pump-Turbine Generator-Motors
Net Benefits			
Power Marketing Region			17,435,000 ~~$19,064,000~~
Rest of Nation			0
Total			~~$19,064,000~~ 17,435,000
Study Area Employment			
Peak Construction	1,5,9	200	1,080
Operation & Maint.	2,5,9	40	50
Property Values	1,6,9	Value of land improvements not affected in metropolitan area.	Value of housing temporarily inflated in surrounding communities
Property Tax Revenues	1,5,9	Tax revenue from Powerplant: $2,301,000	Property tax revenue lost annually: Agricultural Lands - $4,000 Improvements - 4,300 $8,300 Property tax gain from new residential - $20,000 Net Gain - $11,700
Income Loss	1,5,9		$78,000 lost per year from agricultural land use

1/ See Par. 161

2/ EQ Oriented Plan

3/ NED Plan

northern pike fry would be reared in facilities obtained by expanding an existing fish hatchery. The hatchery facility plan contains 324 one-third acre ponds with the same water surface area as the rearing ponds. The fingerlings would be transported from the hatchery to the areas of enhanced forage base and released into the lakes. The following paragraphs summarize the effects displayed in the System of Accounts Tables.

191. National Economic Development: (Displayed in Table D-16) Both Rearing Ponds and the Fish Hatchery achieve net positive benefits. The gross benefits for both plans are identical since the design output and aquatic habitat improvement are equivalent. Plan A has net benefits of $716,700 and a benefit-cost ratio of 3.0; Plan B shows net benefits of $347,300 and a benefit-cost ratio of 1.5. The substantially higher cost of Plan B results from the extensive plumbing for water supply and treatment, additional levees in conjunction with the 324 ponds, construction of catching basins, and the cost of transporting the fingerling pike from the hatchery to the release sites.

192. Environmental Quality: (Displayed in Table D-17) Plan A, EQ plan, has net positive contributions to the environmental quality account and has no major adverse effects on the environment. Approximately 2,400 acres of denuded shoreline will be vegetated resulting in a much improved habitat and reduced erosion in both the inundated and exposed condition. Much of the 140 acres of terrestrial habitat to be destroyed by the rearing ponds supports little vegetation. Seeding the rearing ponds when they are not in use will result in a habitat enhancement. Construction of the pipeline and access roads will have minimal effect. The environmental effects of Plan B are essentially the same except the hatchery facilities will displace 150 acres of crop and recreation land rather than land of lesser habitat quality.

193. Social Well-Being: (Displayed in Table D-18)
The fishery output, resultant visitation, and social well-being effects of both plans are essentially identical. The significant positive effects include strengthening and broadening the adjacent communities' economic base, improving recreation opportunities, enhancing the aesthetics of the shoreline and aiding in reducing community decline and outmigration. Probable adverse effects include increased noise during construction and some decline in public safety as a result of increased visitation for both plans.

194. Regional Development: (Displayed in Table D-19)
Plan A will provide considerably more net regional benefits than Plan B. Induced project construction employment and visitor expenditures estimated at nearly \$1.3 million, will be essentially the same for both plans. Plan B will require 150 acres of private land which will result in a \$750 tax loss on agricultural land. For both plans, however, increased sales will result in an additional \$86,000 annually in regional sales and gas tax revenues.

195. Selection: Restoration of a northern pike fishery at Lakes Oahe and Francis Case by construction of 12 nine-acre rearing ponds and enhancement of 2,400 acres of shoreline and littoral zone (Plan A) was selected on the basis of the following criteria of primary significance.

Plan A maximizes net benefits and is twice as efficient as Plan B.

Plan A maximizes EQ benefits. Plan B will displace 150 acres of crop or residential land with the hatchery facility while Plan A will convert 140 acres of less valuable terrestrial habitat to rearing ponds and to seeded habitat when the ponds are not in use.

RECREATIONAL DEVELOPMENT - MISSOURI RIVER

196. Paragraph C-164 reported that current Statewide Comprehensive

TABLE D-16 SYSTEM OF ACCOUNTS RESTORATION OF TROPHY FISHING

NATIONAL ECONOMIC DEVELOPMENT

	Coding 1/	Plan A 2/ Rearing Ponds	Plan B 3/ Fish Hatchery
Beneficial			
Increased Income	2,6,9	$1,080,000	$1,080,000
Adverse			
Investment Cost	1,6,9	4,270,100	10,081,700
Annual Costs			
Interest and Amortization	2,6,9	285,200	673,400
Operation and Maintenance and Replacement	2,6,9	78,100	59,300
Total		$ 363,300	$ 732,700
Net Performance			
Net Benefits		$ 716,700	$ 347,300
Benefit/Cost Ratio		3.0	1.5

1/ See Par. 161

2/ NED, EQ Plan

3/ Code 10

TABLE D-17 SYSTEM OF ACCOUNTS
RESTORATION OF TROPHY FISHING

ENVIRONMENTAL QUALITY

	Coding 1/	Plan A 2/ Rearing Ponds	Plan B 3/ Fish Hatchery
BIOLOGICAL PARAMETERS			
Habitat			
Aquatic	1,6,9	Approximately 2,400 acres of denuded terrestrial area will be seeded of which a considerable portion will be inundated during the summer months. This seeded area will represent markedly improved habitat in either the exposed or inundated condition.	Same as Plan A.
Terrestrial	1,6,9	One hundred forty acres of terrestrial habitat, currently in public ownership, will be converted by the construction and operation of 12 on-site rearing ponds. Access road construction of approximately 2-1/2 acres will take place in the area of existing trail, and will have a minimal effect on existing habitat. Increased visitation will result in song habitat degradation in these areas. Seeded areas which do not become inundated will result in habitat conditions superior to those existing in the denuded area.	One hundred fifty acres of terrestrial habitat currently in crop or recreation use will be converted to 324 one-third acre ponds and levees. No additional road construction will be necessary.
Biota			
Mammals	1,6,9	Small mammals occupying the 140 acres of destroyed habitat will be displaced.	Small mammals occupying the 150 acres of destroyed habitat will be displaced.
Birds	1,5,9	Those species occupying the 140 acres of destroyed habitat will be displaced.	Same as Plan A - 150 acres
Fish	1,6,9	Increased numbers of prey fish species in the areas of habitat improvement. Approximately 5 million northern pike fingerlings stocked annually (3 million in Lake Oahe, 2 million in Lake Francis Case). Fish species existing in the habitat improvement area may show population increases due to the improved forage base.	Same as Plan A except higher risk of fingerling mortality during transportation to release sites.
Insects	1,6,9	Increased numbers of insects and other invertebrates will occupy the areas of habitat improvement.	Same as Plan A.
POLLUTION PARAMETERS			
Water	1,6,9	No significant detrimental effects. Cattle fencing and vegetation will stabilize shoreline areas resulting in erosion abatement and perhaps slight or localized increases in water quality due to lowered turbidity and more stabilized conditions.	Same as Plan A.
Air	1,6,9	No significant effect.	Same as Plan A.
Noise	1,6,9	Some noise increase during construction phase.	Same as Plan A.
MAN-MADE RESOURCES	1,6,9	Lakes Oahe and Francis Case restored as regionally and nationally important outdoor recreation fishery resources.	Same as Plan A.

1/ See Par. 161
2/ NED, EQ Plan
3/ Code 10

TABLE D-18 SYSTEM OF ACCOUNTS RESTORATION OF TROPHY FISHING

SOCIAL WELL-BEING

	Coding 1/	Plan A 2/ Rearing Ponds	Plan B 3/ Fish Hatchery
Recreational Opportunities	1,6,9	Establish and maintain a viable trophy northern pike fishery in Lakes Oahe and Francis Case and stimulate use of related recreation resources within local and regional boundaries.	Same as Plan A.
Community Growth	2,5,9	Development of services, facilities, and related employment opportunities in surrounding communities to serve visitors attracted from beyond the commuting region.	Same as Plan A.
Educational Opportunities	1,6,9	Provide 4-8 weeks experience and employment in fishery development and operation for 5 graduate students.	Little or no education opportunities since operation will be conducted by full time hatchery employees.
Community Cohesion	1,6,9	Construction at 12 sites will provide employment opportunity for equipment operators and laborers and also diversify the economic base of the region.	Same as Plan A except construction will be limited to a single location and employment opportunity available for additional persons.
Aesthetic Value	1,6,9	Visual appearance enhanced as vegetation replaces 2,400 acres of denuded shoreline. Ponding areas, currently denuded of vegetation, converted to pool and seeded when not in use.	Same as Plan A except crop and/or recreation land converted to fish hatchery.
Population	2,5,9	Economic opportunity will attract entrepreneurs to serve increased commuter and transient tourist trade and reduce regional outmigration.	Same as Plan A.
Noise	1,6,9	Minor increase in noise at 12 sites during construction of pipeline, access roads, and paved levee. Aircraft used for littoral zone seeding will increase noise for a few days over a 5-year period.	Moderate increases in noise concentrated at one site over construction period. Aircraft seeding for a few days over 5-year period will increase noise.
Health	2,5,9	Increased visitation will induce crowding, pollution, crime, and fire hazard.	Same as Plan A.

1/ See Par. 161
2/ NED, EQ Plan
3/ Code 10

TABLE D-19 SYSTEM OF ACCOUNTS RESTORATION OF TROPHY FISHING

REGIONAL DEVELOPMENT

	Coding 1/	Plan A 2/ Rearing Ponds	Plan B 3/ Fish Hatchery
Net Benefits			
Region (100-Mi. radius)	2,5,7,9	$930,600	$852,400
Rest of Nation	2,5,7,9	-213,900	-505,100
Total		$716,700	$347,300
Increased Employment			
Project			
Construction (man-years)	1,5,7,9	30	70
Operation and Maintenance (man/year)	2,5,7,9	<1	<1
Seasonal Service (number)	2,5,9	300	300
Value of Increased Income	2,5,9	$1,290,000 increased sales	Same as Plan A
Taxes	2,5,9	$37,000 increased sales tax	$750/yr tax loss on acquired land. Otherwise same as Plan A.
	2,5,9	$49,000 increased gas tax	
	2,5,9	$86,000 Total tax	

1/ See Par. 161

2/ NED, EQ Plan

3/ Code 10

Outdoor Recreation Plans document the desirability of more public access to the river in response to unmet demands for boating, fishing and hunting (with camera, gun or bird and animal identification guides). One method by which the States could accomplish this development would be through authority and funds provided by the Land and Water Conservation Fund Act of 1965 - PL 88-578. Such unilateral activity on the part of individual states is tantamount to opting in this report for no new Federal action. PL 89-72, however, requires that consideration be given to opportunities for outdoor recreation during the planning for water resource projects and that non-Federal bodies be given the opportunity to cost share recreation development with the Federal Government on a 50-50 basis. Accordingly, this report treats recreational development as an equal partner with other developmental activity in the study area to the extent that interest in non-Federal sponsorship is evident. In the plan description, then, and in the discussion of non-Federal responsibilities recreational development is treated as an opportunity available throughout the bank stabilization works.

DESIGNATION UNDER PL 90-542

197. The Wild and Scenic Rivers Act (PL 90-542) identifies the U. S. Departments of the Interior and Agriculture as the Federal agencies to study rivers for their eligibility and proposed classification under this Act. The secretaries of the two departments have delegated the responsibilities for such studies to the BOR and the Forest Service, respectively. BOR has provided assistance in the present study of the Gavins Point Dam to Ponca State Park reach of the river. Inclusion of National Wild, Scenic and Recreational River findings and recommendations in this report, then, is based on the BOR's involvement and the several Congressional actions directing Corps' studies of the Missouri River. Any recommendation for designation under the Wild and Scenic Rivers Act is dependent upon the finding of outstandingly remarkable natural and cultural values worthy of preservation under the terms of the Act. These values have been found to be present, and the river is recommended for designation

and management under the Recreation River classification. This course of action constitutes Plan A.

198. The alternative to designation under the Wild and Scenic Rivers Act is river access in conjunction with bank stabilization under the authority of PL 89-72 (Plan B). This is the procedure followed in the remaining river reaches as described in paragraph D-196. It provides access and service roads, boat launching, sanitary, and related recreational facilities that would accommodate an anticipated increase of nearly six percent in the one million annual visitors estimated to be currently using the river reach. Present usage centers around the developed downstream recreation areas at Gavins Point Dam; Ponca State Park, Nebraska; Clay County recreation area just outside of Vermillion, South Dakota; several county access points on the Nebraska and South Dakota sides of the river; and two wildlife management areas on the South Dakota side of the river. Initial development cost of the river access points is estimated at $346,000.

199. Designation of the river reach under the Wild and Scenic Rivers Act permits preservation of specific river features that are recognized as having outstandingly remarkable natural values. These include the river setting at Goat Island including the entrance of the James River and Missouri chutes paralleling Goat Island; the general high bank shoreline forest dominated by cottonwood trees; clusters of sand bars; and the Nebraska wooded bluffs, particularly at river miles 763, 776, and 787. In addition, preservation of the sand bar clusters in the river between Gavins Point Dam and Ponca State Park permits their continued nesting use by the Interior Least Tern, a rare shorebird that is being studied for inclusion on the Endangered Species list, and use as a most significant spring migration staging area for waterfowl. The "between-high bank" physiographic features of the river, which include deep holes, shallows, near quiet water chutes, fast river current, stable river bottom and shifting sand bottom, may be the last remaining production area

for the paddlefish in the Missouri River below Gavins Point Dam. Finally, preservation of the present river setting permits contemporary and future Americans to see the river much as it has been throughout its significant history.

200. To accomplish the needed preservation, about 14,500 acres of scenic and recreational easement are required at an approximate cost of $1.4 million. Selected "soft" structures are aimed at preservation of elements such as islands within the high banks, at an **approximate cost of $1.5 million.** Only those types of structures shown by evaluation under Section 32 to be compatible with Wild and Scenic River designation are to be incorporated. In the absence of such designation, no protection riverward of the high banks will take place, resulting in ultimate loss of the aesthetic values in question.

201. Development to accommodate public use of this reach of the river includes acquisition of about 424 acres of land in fee and construction of sanitary, river access and camping facilities. In addition, existing river access facilities operated by State and local government would be upgraded as necessary to permit all weather use. Recreation development costs would amount to about $3.4 million and would initially support 500,000 more visitors per year, with an ultimate increase to 750,000. This increase for Plan A as compared to Plan B is attributed by BOR to regional and national recognition stemming from Wild and Scenic River designation. A comparison of Plan A and Plan B is made in the System of Account tables as summarized in the following paragraphs.

202. National Economic Development: (Displayed in Table D-20) Plan A provides for an average annual increase of 677,500 visitor days consisting of general recreation activities, and specialized high value recreation activities of hunting, fishing, and canoeing. The NED value of these activities is estimated at over $3.3 million

per year providing net NED benefits of $2,645,200 with a benefit-cost ratio of 5.0. The alternative of providing access points, Plan B, will accommodate 41,000 initial and 61,000 ultimate visitor days with an annual value of nearly $108,000, with net NED benefits of $69,200 and a resultant benefit-cost ratio of 2.8.

203. Environmental Quality: (Displayed in Table D-21)
The maintenance of existing environmental quality is one of the major purposes of Plan A. The major physiographic elements preserved are the two largest islands, natural high-bank vegetation as seen from the river, lands presently used for plow agriculture, and some marshy accretion lands. Preservation of these elements will significantly affect the future potential of terrestrial wildlife populations, especially the larger mammals, such as deer, and some songbirds. Aesthetic and cultural resources are retained for public use under this plan. Under Plan B gradual continuing loss of the high bank natural vegetation in favor of farming is anticipated, along with increasing uncontrolled use of riparian lands for cottage and trailer sites. The large islands will ultimately be lost. High bank wildlife population will be significantly and adversely affected and existing environmental quality will be reduced.

204. Social Well-Being: (Displayed in Table D-22)
Plan A provides significant impacts in the local area as the overall quality of life is enhanced by preservation and development of recreation resources. The influx of recreation visitors will modify the local social structure by introducing a new industry into the area, based upon seasonal recreation visitation. Plan B will provide basic accessibility to recreation resources and benefit primarily the local populace as recreation activities are made more available. Increased visitation is estimated to reach less than one-tenth of that expected with Plan A.

TABLE D-20 SYSTEM OF ACCOUNTS
MISSOURI RIVER RECREATION DEVELOPMENT
GAVINS POINT DAM TO PONCA, NE

NATIONAL ECONOMIC DEVELOPMENT

	Coding 1/	Plan A 2/ Wild and Scenic Rivers Act PL 90-542	Plan B 3/ Federal Water Project Recreation Act PL 89-72
Beneficial			
Increased Income	2,6,10	$3,306,000	$107,600
Adverse			
Investment Cost	1,6,10	7.412.000	346,000
Annual Cost			
Interest and Amortization	2,6,10	495,000	23,100
Operation and Maintenance and Replacement	2,6,10	165,800	15,300
Total		$ 660,800	$ 38,400
Net Performance			
Net Benefits		$2,645.200	$ 69,200
Benefit/Cost Ratio		5.0	2.8

1/ See Par. 161

2/ NED, EQ Plan

3/ Coding: "9" replaces "10" for all Plan B effects.

TABLE D-21 SYSTEM OF ACCOUNTS
MISSOURI RIVER RECREATION DEVELOPMENT
GAVINS POINT DAM TO PONCA, NE

ENVIRONMENTAL QUALITY

	Coding 1/	Plan A 2/ Wild and Scenic Rivers Act PL 90-542	Plan B 3/ Federal Water Project Recreation Act PL 89-72
BIOLOGICAL PARAMETERS			
Habitat			
Aquatic	1,5,10	Highly variable and reasonably stable aquatic habitat will be maintained. Bank stabilization structures will be planned for greatest possible use by aquatic life.	Variable and reasonably stable aquatic habitat will continue to exist. Less emphasis on wildlife and aquatic habitat needs when designing bank stabilization structures.
Terrestrial	1,6,10	Preservation of natural values through recreation easement on 12,800 acres of land, scenic easement on 1,700 acres, and fee acquisition of 420 acres. Preservation of existing high bank and bluffland vegetation, and the changing (dynamic) character of lowland and sand bar vegetation will contribute to long-term well-being of the other terrestrial lifeforms.	High bank habitat will be greatly reduced over time through subdivision and agricultural improvements.
Biota			
Mammals	1,6,10	High bank habitat will be preserved, benefiting the larger mammals, especially deer. Changing lowlands will provide habitat diversity.	The larger mammals will be greatly reduced through development and high bank vegetation loss.
Birds	1,5,10	Ratio of land and water loving birds will remain generally the same, except for those lost through off-project development. Increased human activity on the project may reduce nesting activity of shorebirds and waterfowl. Waterfowl hunting intensity will be increased to some extent.	Increase in low sand bars will benefit waterfowl and shorebirds. Reduced high bank vegetation will decrease songbird and gamebird habitat.
Fish	1,5,10	Diversity of submerged lands will be retained. Reduction of high bank erosion will ultimately reduce the number of snags - an important cover for fish, especially large catfish.	Diversity of submerged lands will be retained. Reduction of high bank erosion will ultimately reduce the number of snags.
Insects	1,6,10	Numbers of terrestrial insects will be preserved.	Numbers of terrestrial insects will be reduced through habitat loss and agricultural development. Usable habitat for aquatic insects will probably not be significantly changed.
POLLUTION PARAMETERS			
Water	1,6,10	No significant effect.	No significant effect.
Air	1,6,10	No significant effect.	No significant effect.
Noise	1,5,10	Noise from irrigation pumps and other riparian sources will be controlled to some extent through easement conditions.	Noise factors from riparian sources will not be controlled.

1/ See Par. 161
2/ NED, EQ Plan
3/ Coding: "9" replaces "10" for all Plan B effects.

ABLE D-22 SYSTEM OF ACCOUNTS MISSOURI RIVER RECREATION DEVELOPMENT GAVINS POINT DAM TO PONCA, NE

SOCIAL WELL-BEING

	Coding 1/	Plan A 2/ Wild and Scenic Rivers Act PL 90-542	Plan B 3/ Federal Water Project Recreation Act PL 89-72
Health and Safety	1,6,10	Marking main channel will reduce boating hazard. Provision for safe access to river recreation and scenic areas.	Safe access to river and scenic areas by providing boat ramps and parking areas.
Community Well-Being	1,6,10	Overall quality of life in the project zone of influence will be enhanced through preservation and availability of resources of public value.	Enhancement by provision for local recreation activities.
Community Cohesion	1,5,10	Minimal disruption of riparian life style and improved personal security due to protection afforded by the project.	Minimal disruption of community cohesion.
Recreation Opportunities	1,6,10	Public recreation opportunity will be enhanced through preservation of vegetation, wildlife, and natural values and addition of public access to river resources, including islands through acquisition and easement. A comprehensive recreation resources management and applied recreation management will protect and preserve potential and enable maximum feasible levels of use.	River access for local populace.
Aesthetic Values	1,5,10	Increased aesthetic value through preservation of riverside vegetation, current land use patterns, vistas, and wildlife habitat.	Continued aesthetic degradation within high banks, loss of islands and aesthetic vistas.
Public Facilities	2,6,10	Addition of public access and recreation facilities.	Limited number of recreation support facilities.
Public Services	2,5,10	Increase in public services to accommodate initial recreation visitation of 500,000. Additional recreation services through ranger and maintenance activities.	Small increase in public services to accommodate initial recreation visitation of 55,400.
Desirable Community Growth	2,5,10	Preservation of land and water resources, improved quality of life within zone of influence, and increased leisure opportunity, make the region a more desirable place to live and work.	Minor positive effect.

1/ See Par. 161
2/ NED, EQ Plan
3/ Coding: "9" replaces "10" for all Plan B effects.

TABLE D-23 SYSTEM OF ACCOUNTS
MISSOURI RIVER RECREATION DEVELOPMENT
GAVINS POINT DAM TO PONCA, NE

REGIONAL DEVELOPMENT

	Coding 1/	Plan A 2/ Wild and Scenic Rivers Act PL 90-542	Plan B 3/ Federal Water Project Recreation Act PL 89-72
Net Benefits			
Region	2,5,7,10	$ 3,244,400	$ 80,750
Rest of Nation	2,5,7,10	- 599,200	-11,550
Total	2,6,7,10	$ 2,645,200	$ 69,200
Increased Employment			
Project Construction	1,5,7,10	60	10
Seasonal Service	2,5,10	390	30
Increased Income	2,5,10	5,000,000	400,000
Tax Revenues			
Gasoline Tax	2,5,10	170,000	14,000
Sales Tax	2,5,10	170,000	12,000
Total	2,5,10	$ 340,000	$ 26,000
Business and Industrial Activity	2,5,10	Growth in recreation industry and associated services.	Small growth in recreation industry.

1/ See Par. 161

2/ NED, EQ Plan

3/ Coding: "9" replaces "10" for all Plan B effects.

205. Regional Development: (Displayed in Table D-23) Plan A will have a significant impact on the regional economy as the recreation services industry develops to serve the large influx of recreationists who are estimated to spend $5 million annually. Construction impacts will be relatively small but induced seasonal employment could number nearly 400. Taxing revenues in the areas of gasoline sales and sales tax could approach $340,000. Plan B would have impacts of the same type, but on a much smaller scale as recreation expenditures are estimated at around $400,000 annually. Seasonal employment could reach 30, while taxing revenues could approach $26,000 per year. Both plans should have a positive effect on industrial development in the area, since recreation availability and accessibility are positive characteristics desired by plants seeking expansionary locations.

206. Selection: Since Plan A better preserves an environmental resource of national importance and at the same time is the more efficient investment as judged by economic criteria, it was chosen as the recommended plan.

Unfinished Business

207. Final selection of the plan elements to be recommended in this report has left several problems and opportunities identified but not finally disposed of. These items are listed here as a reminder of actions needed at some future date, over and above those actions which would be accomplished through the routine conduct of daily business.

Water Use

208. Paragraphs C-93 through C-98 discussed the steps which must be taken along the way toward a managed program of resource use as contrasted to unbridled competition for that resource. Each passing month sees more widespread acknowledgement that the steps should be undertaken soon; the unresolved question is how to begin. The National Assessment and the USBR's Total Water Management Study have focused attention on the present extent of the water supply and on identification of the location and amount of consumptive uses. These new data in conjunction with a streamgaging record reaching back, in part, nearly eight decades, should make possible a well-documented baseline condition by the early 1980's. Consensus over future conditions appears to lie considerably farther down the road. Still to be made are the policy decisions; choices based upon an evaluation of alternative uses -- trade-offs, to use a term in current favor. That these choices are beyond the prerogative of the Corps of Engineers to make does not mean they should be neglected.

Waterlogging

209. Paragraph D-116 mentioned the possibility that future waterlogging problems at Buford-Trenton might result in the proposal of a multi-million dollar land acquisition program. Such an action would require more supportive data than is presently available. Well logs need to be continued and additional wells added if questions arise concerning the geographic extent of the problem. Systematic records of crop production would also be helpful in establishing the extent and magnitude of lost production by tract.

Hydro-Power

210. Paragraphs D-139 and D-144 deferred final consideration of hydro-power additions at Oahe and Fort Randall and pumped storage adjacent to Lake Sakakawea until the decade of the 1980's. At that time both the energy and water use policies of the region may have further evolved, pointing the way to a more clear choice. To provide a mechanism for this further examination, the response of

this report to Congressional authorization of hydroelectric power studies is interim in scope. After potential contributions of those projects here deferred have been assessed in the light of newly developing national policies, a final report will close out this study. Meanwhile, the option to construct low cost peaking capacity remains open at virtually no cost in lost energy, thanks to the size of existing power installations.

211. At Fort Randall, extensive study of the downstream effects of additional power peaking discharges had been completed prior to the decision to defer further consideration. This work included the conduct of field velocity measurements and bed material classification as well as zero-discharge, aerial photography and stage readings similar to the work done at Garrison and described in Section E, Hydro-Power Facilities - Garrison. Deferral of power additions at Fort Randall has removed need to include that material in this already voluminous report; to preserve it for future consideration, however, a special technical report documenting the data will be prepared.

SECTION E

THE SELECTED PLAN

THE SELECTED PLAN

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SECTION E

THE SELECTED PLAN

1. This section describes the selected plan under the three major topics of bank protection, hydro-power, and recreation, fish and wildlife. Plan accomplishments and effects are identified, including the cost of bank protection. Economics of the other features are discussed in Section F. Information on design, construction and operation and maintenance is included to the extent necessary to substantiate the expected plan accomplishments and effects.

Bank Stabilization

2. The selected plan provides for bank protection measures in the reaches downstream from Fort Peck, Garrison, Oahe, Fort Randall and Gavins Point Dams in furtherance of Congressional expressions in the 1974 and 1976 Water Resources Development Acts, Sections 32 and 161, respectively.

Plan Description

3. It is proposed to control bank erosion by **employing river management techniques using a variety of structural bank protection**

measures in combinations that are appropriate for local river conditions. Typical elements (Fig. E-2 thru E-8) are flow control structures, vane dikes, windrow revetment, artificial hardpoints, composite bankline revetment, sand fill revetment, and tree retards. Still other techniques may be developed which will meet the overall objective of the plan, which is to prevent loss of valley lands by protecting the high river banks, while leaving the river environment between the high banks in its present condition with no loss in water area. Of necessity, site treatment detailed here is based on river conditions existing at present. Since the location of the river channel is extremely variable and points of attack on the banks shift from season to season, specific types of structures and their locations will be adjusted at the time of construction to insure compatibility with prevailing field conditions.

4. Reductions in the long-term average flow of the Missouri River, as a result of future growth in depletions, will not diminish the need or function of the bank protection works. Field observations indicate that even though an overall correlation exists between rates of bank erosion and streamflow rates, very high rates of erosion still occur at specific locations during low flow periods. This occurs as a result of the continuing tendency for the main channel to migrate in and between the sand bar and to be directed toward the high overbank lands either at high flows or at low flows. In addition, the possibility of high basin runoff in any given year will continue to exist regardless of the extent to which future depletions materialize.

SPONSORSHIP

5. Since the basis for this plan element rests in Congressional expressions previously recited, implementation procedures must conform to those expressions. They call for non-Federal sponsors of the works who will provide without cost to the Federal Government:

- Necessary lands, easements, and rights of way;
- Federal indemnity against damages due to the construction;

● Operation and maintenance after project completion.

Letters of intent have been obtained from sponsors of work in the recommended reaches and are discussed further in Section G. No problem is posed by the first two requirements just listed; responsibility for operation and maintenance, however, must be scheduled in an equitable and realistic manner. Failing this, local sponsors may be burdened beyond their resources in the commitment to maintain a project still in the developmental stage. This aspect is discussed further in paragraph E-38, Operation and Maintenance.

SCOPE

6. The plan for the 190-mile reach downstream from Fort Peck Dam consists of work in five critical areas listed in Table E-1 and shown in Plates E-1 to E-5. The plan for the 79-mile reach from Garrison Dam to the headwaters of Oahe Reservoir consists of work in 29 areas listed in Table E-1 and shown on Plates E-6 through E-19. The works already constructed in seven areas under the PL 88-253 authorization for bank protection in the Missouri River-Garrison Dam to Lake Oahe project have been incorporated in the present plan. The remaining sites are presently authorized for construction by the Streambank Erosion Control Evaluation and Demonstration Act, Section 32, Water Resources Development Act of 1974, as amended by Section 161 of the 1976 Act, which specified "multiple sites" in the Garrison reach including 21 sites that are specifically named in the 1976 Amendment. A plan for the five-mile reach from Oahe Dam to the headwaters of Big Bend Reservoir on Plate E-20 includes work necessary to avoid critical erosion to private development along the right bank from the Oahe project boundary downstream to Fort Pierre. The plan for the 36-mile reach from Fort Randall Dam to the Niobrara River consists of work at seven critical areas listed in Table E-1 and presented on Plates E-21 through E-26. The plan for work throughout the 58-mile reach from Gavins Point Dam to Ponca State Park, Nebraska, is presented on Plates E-27 to E-35. The 25 sites

TABLE E-1 EXISTING AND PROPOSED BANK PROTECTION SITES BELOW MISSOURI RIVER DAMS

Missouri River Reach	Site Location 1960 River Mile	Right or Left Bank	Name of Area	Existing Work	Authorized Under Section 32 as Modified By Section 161	Other
Fort Peck	1620.8	R & L	Culbertson Area			X
	1675.8	Right	Poplar River Area Part II			X
	1679.2	Right	Poplar River Area Part I			X
	1739.0	Right	Frazer Lake Area			X
	1759.0	Left	Milk River Hills Area			X
Garrison	1310.0	Right	Custer Flats		X	
	1311.0	Right	Fort Lincoln		X	
	1313.0	R & L	Bismarck-Mandan	1/		
	1316.5	Right	I-94 Highway		X	
	1316.5	Left	Pioneer Park		X	
	1320.5	Left	Burnt Creek		X	
	1323.0	Left	Eagle Park	2/		
	1326.5	Left	Indian Mound		X	
	1327.5	R & L	Square Butte	1/		
	1332.0	R & L	Dry Point	1/		
	1334.5	Right	Horseshoe Butte		X	
	1335.7	Left	Woganport		X	
	1338.5	Left	Price Part II		X	
	1341.0	Right	Price Part I		X	
	1343.5	Right	Pretty Point		X	
	1345.2	Left	Wildwood (Upper)		X	
	1345.0	Right	Sanger		X	
	1350.0	R & L	Painted Woods	1/		
	1355.0	Right	Washburn			4/
	1357.5	Left	Lewis & Clark Camp		X	
	1360.0	Left	Coal Lake Coulee		X	
	1362.0	R & L	Lake Mandan	1/		
	1366.5	Left	Sandstone Bluff II		X	
	1368.0	Left	Sandstone Bluff I		X	
	1371.5	Right	Fort Clark Power Plant	1/		
	1372.0	Right	Stanton Power Plant	1/		
	1374.0	Left	Knife Point Part I		X	
	1379.5	Right	Knife Point Part II		X	
	1385.0	Right	Hancock		X	
Oahe	1067.5	Right	Fort Pierre			X
Fort Randall	851.5	Right	Choteau Creek			4/
	862.0	Left	Willow Bar			4/
	864.0	Left	Greenwood			4/
	868.0	Right	Sunshine Bottom			4/
	874.5	Left	Yankton Sioux Tribal			4/
	875.0	Right	Ninemile Gulch			4/
	878.0	Right	Eagles Roost			4/
Gavins Point	755.5	Left	Elk Point			4/
	759.0	Right	Ionia Bend			4/
	760.5	Right	Ionia Bend			4/
	764.5	Left	Bolton Bend			4/
	767.0	Right	Ryan Bend		X	
	771.0	Left	Vermillion River Chute	2/		
	772.5	Left	Fairview			4/
	775.0	Right	Mulberry Bend		X	
	777.0	Left	Mulberry Point		X	
	779.0	Right	North Alabama Point			4/

TABLE E-1 (CONT'D)

Missouri River Reach	Site Location 1960 River Mile	Right or Left Bank	Name of Area	Existing Work	Authorized Under Section 32 as Modified By Section 161	Other
Gavins Point	781.0	Left	Clay County Park			4/
	783.5	Left	Vermillion Boat Club		X	
	784.0	Right	Brooky Bottom Road	2/		
	786.0	Left	Vermillion Boat Club Area 2			4/
	790.0	Left	Audubon Bend			4/
	794.0	Left	St. Helena Bend			4/
	796.5	Left	Goat Island			4/
	798.5	Right	Cedar County Park			4/
	800.0	Right	Campbells Point			4/
	801.0	Left	James River			4/
	803.0	Right	Yankton Reach			4/
	804.0	Left	Rush Island			4/
	805.7	Right	Beaver Creek			4/
	806.0	Left	Yankton Riverfront			4/
	806.6	Left	Sacred Heart Hospital	3/		

1/ Authorized under PL 88-253, 1963
2/ Authorized under Section 32, PL 93-251, 1974, under construction as of 1 January 1977
3/ Authorized under Section 39, PL 93-251, 1974
4/ These sites are in specifically-named river reaches where "multiple sites" were authorized by Section 32, PL 93-251, but are not included in the present Section 32 program due to funding limitations.

are listed in Table E-1. Six of the sites have been funded and are proposed for construction during 1977 under the Streambank Erosion Control Demonstration Act, Section 32 of the Water Resources Development Act of 1974. The existing bank protection at Sacred Heart Hospital, authorized by Section 39, PL 93-251, has been incorporated in the present plan.

7. Inspection of Plates E-1 through E-35 shows that the initial structural system will provide direct protection to only a portion of the total length of erodible river banks in the project reaches. These are areas where erosion is presently occurring or imminently threatens. Protection of these areas will eliminate the source of new bed sediment and the changes in bank alignment that are the principal cause of channel shifting within the riverine area between high banks. Even though all high banks which lack either natural or man-made protection are subject to eventual attack by the river, this more stable regime will reduce the tendency. It is not possible to predict very far in advance the location of future erosion, the time of occurrence, or the most suitable protective techniques. In the face of this uncertainty, it would be most

uneconomical to protect all potentially erodible banks with initial construction. The most feasible plan is to take care of any threatened area as the need develops from year to year. After the initial construction is in place, it is expected that channel changes will be slowed enough that new needs can be predicted and satisfied within a reasonable maintenance program.

8. Lands shown on Plate E-2 which abut the Fort Peck Indian Reservation in Montana and on Plates E-22 through E-26 which abut the Yankton Indian Reservation in South Dakota will not follow the sponsorship procedures discussed in Paragraph E-5. Instead, it is proposed to enter into a memorandum of agreement with the Bureau of Indian Affairs in lieu of Section 221, PL 91-611.

REACHES OMITTED FROM THE PLAN

9. The plan, as discussed in the previous seven paragraphs and displayed on Plates E-1 through E-26, was developed to respond to identified areas of active erosion. On non-Federal lands the requirements of sponsorship discussed more fully in Section G insure, among other things, that bank protection is not provided along extensive reaches where no one wants it. Federally-owned lands obviously deserve the same consideration. In the Fort Randall reach are two sites identified as Eagles Roost - river mile 878, and Nine-Mile Gulch, river mile 875 and shown on Plate E-21. They lie on tracts of land described in paragraph C-116 as the Karl E. Mundt National Wildlife Refuge and managed by the U. S. Fish and Wildlife Service. Although personnel of that agency have measured high bank caving of as much as ten feet of tree-covered prime eagle roosting habitat in one season, concern over possible habitat degradation has caused their present opposition to the stabilization work. The area is retained in this section to document a problem area, but is not included in the cost estimate.

RIVER ACCESS

10. The incorporation of recreation development -- specifically

river access sites -- into the bank protection program is dependent on the identification of local sponsors willing to operate and maintain the site and to share 50 percent of the original cost. This requirement determined the number of sites recommended here. Their extent does not represent a full response to the recreational demand; rather, it represents the financial ability of identified local sponsors. It is possible additional sponsorship will be proposed during advanced design.

11. Approximate locations of the three sites recommended in North Dakota are:

- The vicinity of Washburn off State Highway 200A,
- The vicinity of Bismarck off Interstate 94,
- South of Mandan.

The approximate locations of the two sites recommended below Fort Randall are:

- East of Gross, Nebraska,
- North of Verdell, Nebraska.

Lack of sponsorship prevents additional river access sites from recommendation for the reach of river below Fort Peck or below Fort Randall at this time. Access to the river below Gavins Point is included in the discussion of PL 90-542 designation.

MITIGATION

12. In light of the efforts which will be exerted during design and construction of the bank protection works to insure compatibility with current riverine habitat and bank alignment, no mitigative measures are recommended as being needed.

Evaluated Accomplishments

13. The primary accomplishments that will result from the bank protection plan are:

- Prevention of the permanent loss of 272 acres per year of valley lands below Fort Peck, Garrison, Oahe, Fort Randall, and

Gavins Point Dams, based on estimates that the proposed measures would control about 80 percent of the estimated future land losses in all reaches, except for Fort Peck. In this reach the proposed measures are estimated to control about 20 percent of the land losses. Components of this averted loss are roads, bridges, residences, recreation lands with improvements, woodlands, pasturelands, and croplands.

- Stabilization of the location of the high river banks along the valley lands.
- Contribution of an essential element to proposal for designating the Gavins Point reach as a National Recreation River under the National Wild and Scenic Rivers Act.
- Provision of river access to pleasure boaters, fishermen and hunters to the extent of 15,000 visitor days per site per year for a total of 75,000 visitations annually.

Environmental Effects

14. The significant reduction in the rate at which Missouri River valley lands erode into the river is considered the most significant impact of the bank protection plan. Other less significant impacts include procurement of the rock for use as riprap and the act of physically constructing the protective structures.

15. At the present rate of erosion, about 437 acres of high bank valley lands are being lost annually. The valley lands (viewed as flood plain lands extending about one mile back from the river shore) are made up of cropland, 64 percent; woodland, 11 percent and grassland, 22 percent. The remaining three percent includes municipalities, roads, marsh and water. At the river's fringe (a 500 foot border landward of the river bank) the make up of the terrestrial plant cover is about 25 percent cropland, 32 percent woodland, and 29 percent grassland; the remaining 14 percent is made up of roads, sand dunes, and marsh. Biologists from the U. S. Fish and Wildlife Service, States of Montana, North Dakota, and South Dakota, and the Corps of Engineers

evaluated the flood plain lands in specific transects for their value to wildlife in the open reaches below Fort Peck, Garrison and Fort Randall; the Corps assessed the wildlife value of the land cover below Gavins Point for wildlife. An assumption has been made that similar land cover throughout each open river segment has value for wildlife similar to the surveyed transects in that open river reach. Based on this assumption and a wildlife value rating of one to ten, with ten being the most valuable, the average woodland in the flood plain was judged to have a wildlife value of almost eight (quite valuable), grassland and valley cropland have wildlife values of just over five (average value).

16. The fact that almost 20 percent of the valley woodland is found in the river fringe, coupled with the fact that woodland does not exist outside the Missouri River valley in the study area except for small amounts of farm woodlots and other drainages' fringe woodland makes the effect of keeping the high bank valley lands from eroding very beneficial. The importance of this effect is intensified because the Missouri River woodland is not being replenished to the same extent as it was before completion of the main stem dams virtually stopped overbank flooding - a condition that initiated the cottonwood-dominated woodland successional development. Flood waters carry cottonwood seed; upon recession of flood waters cottonwood seeds germinate, producing seedlings and saplings, and eventually, mature stands of cottonwood. Today, cottonwood seed germinates only on sand bars and low bank land (the only lands being flooded) where seedlings and many saplings develop. However, cottonwood trees fail to mature on these lands because the ground water table is too close to the surfaces to permit mature growth of the cottonwood root system. Therefore, the remaining cottonwood-dominated, high bank woodland is a unique and irreplaceable habitat type; its loss most significant and its protection most desirable. Loss of the other major wildlife habitat types -- cropland and grassland -- is not considered significant because both habitat types are common in the

flood plain and the adjacent uplands.

17. Since the cessation of floods below the main stem dams there has been considerable land use alteration resulting in the reduction of woodland and an increase of cropland. Escalation of cropland value and crops produced, more productive and cost effective farming methods and woodland clearing methods, and improved farm equipment are other significant causes of these land use changes. An indirect effect of bank protection may well be further replacement of woodland by more profitable cropland. However, because much of the remaining woodland (particularly that located on the river fringe) is growing on very sandy soil which is not usually regarded as good quality cropland, the land use change may not be highly significant. Currently, there is considerable interest in irrigation farming on the Missouri River bottomlands where there is an adequate supply of both surface and ground water. Therefore, an indirect effect of bank protection and the resultant conversion of woodland to cropland, may be irrigation of that cropland. Irrigation typically commands the use of agricultural chemicals which could lead to addition of salts in the soil and an additional source of wildlife poison. In relation to the entire agricultural contribution, these effects will be very minor.

18. Protection of the high bank lands will eliminate a principal source of new river bed sediment. A direct consequence will be better river water quality; however, this impact will be insignificant since turbidity levels are already quite low. A secondary effect will be a more stabilized river bed after the initial removal of recently deposited sediment. This effect should provide a somewhat better substrata for growth of benthic organisms, but it is also considered to be insignificant.

19. Rock will be the major building material used in the construction of bank protection structures. It is anticipated that rock

will be obtained from existing quarries (particularly for rock such as quartzite) from quarries opened primarily to supply rock for this construction (particularly for sedimentary rock), and from collecting field stone from prairie hills adjacent to the Missouri River. The environmental effect of mining granite from existing quarries is typically the removal of ground cover prior to excavation. Sedimentary rock found adjacent to the Missouri River, particularly in the lower part of the study area, is the substrate of the Missouri "breaks". To obtain this material the "breaks" overburden is first removed, including the vegetation cover which is typically timber. The visual effects of this operation are much more significant than removal of ground cover and harvest of rock from quartzite quarries. Usually, the timber cover of the Missouri "breaks" is quite valuable to wildlife. Mining of sedimentary rock could harm cultural resources. Even though preservation of the cultural resource data would be effected, the disturbance of the archaeological site and its context would diminish the overall value of the resource. The environmental effects of mining rock, both quartzite and sedimentary rock, is not considered to be significant.

20. In areas along the Missouri River where past glacial action has left a supply of field stone drift, it may be economically feasible to gather the field stone for use in the construction of bank protection structures. This operation usually consists of raking field stone off prairie land and reducing the size of stone too large for such use by fracturing the stone using a crane equipped **with a "headache ball." The effect of this operation is to disburb the soil, causing surface erosion until ground cover can be re-established; temporary reduction of the wildlife numbers; a lessened value of scenery; and a potential requirement for cultural resource mitigation. The amount of prairie land temporarily affected by the removal of field stone for use in the construction of bank erosion structures in comparison with the amount of prairie hills adjacent to the Missouri River in the study area is minimal;**

the environmental effects associated with this operation are considered to be insignificant.

21. The environmental effects of building the bank protection structures will depend upon the type of structure being constructed. Windrow revetments, either piled in prepared trenches or on the ground will have no immediate effect on the aquatic environment. As the rock slough into the river, due to undercutting, to form a barrier between the river and the bank land, the river will become turbid, at least in the immediate area of the sloughing. This effect will be temporary and would have occurred with or without the presence of the rock. Subsequent effects of the rock in the river may be to add aquatic habitat diversity which would be beneficial. The Missouri River bed is composed almost totally of shifting and moving sand; a notable exception is a reach located at the Nebraska-South Dakota state line, composed of rock which provides a most significant sauger and walleye spawning area, and possibly a paddlefish spawning area. The additional rock will provide a firm substrate for colonization of benthic organisms, small cavities that can be used as escape cover by small aquatic animals, and possibly nesting cavities for catfish. Windrowed rock, if placed on the surface of the land, could also provide escape cover and possibly nesting cover for small land animals. In turn, windrowed rock could become feeding sites for predators and hunting sites for man. Windrowed rock placed in trenches and covered with dirt and seeded may be more aesthetically pleasing to man but of little use to small land animals. All other bank protection structures will be constructed in or interfacing with the river causing the immediate disruption of the river bed at the structure site. The effects would, however, be similar to the windrow revetments after sloughing into the river. Construction equipment noise and fumes would be an insignificant, temporary adverse effect. The proposed structures are not designed to diminish the water area of the Missouri River, nor to alter materially the configuration of the river within its high banks.

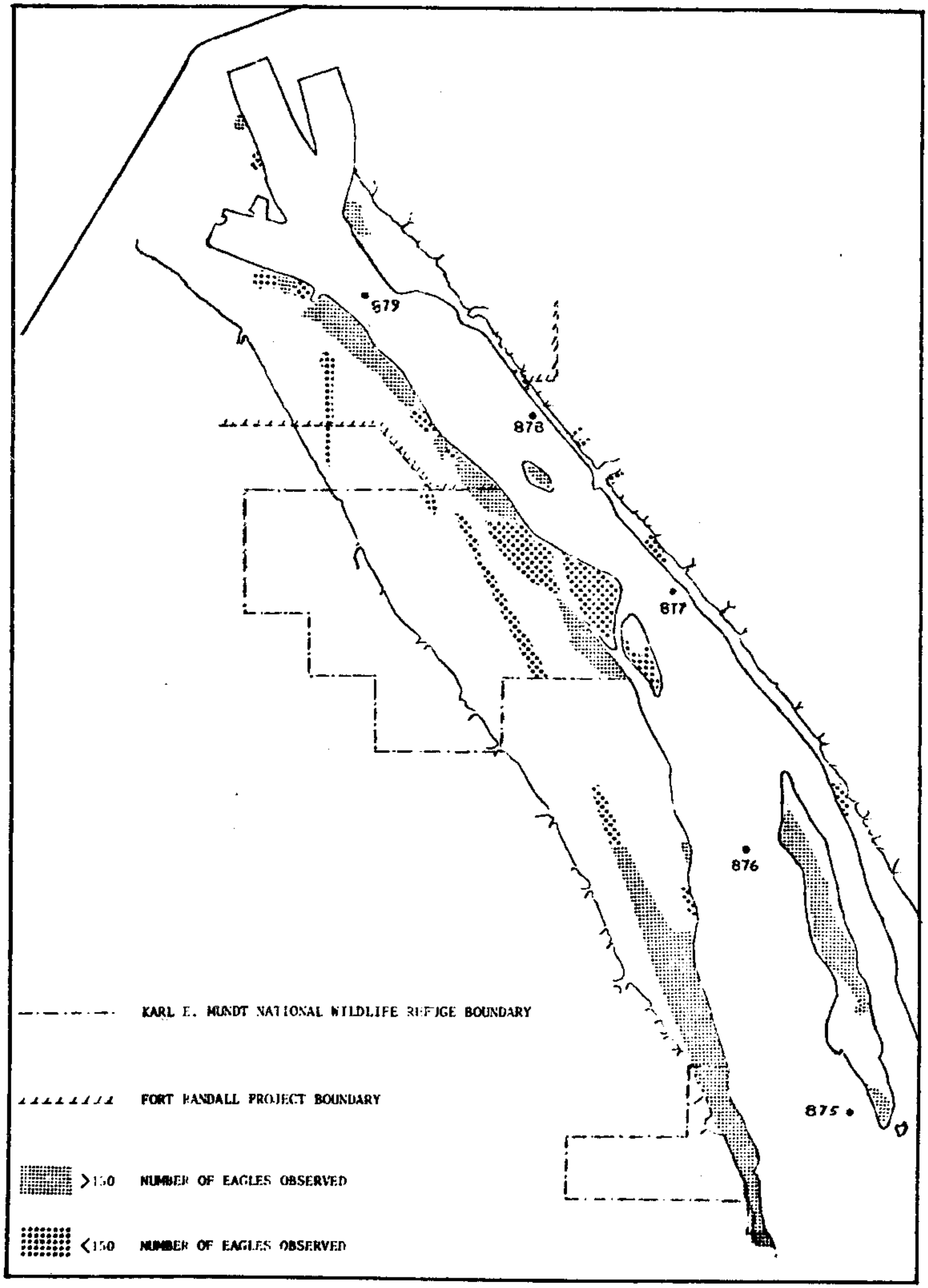
22. The open river reach below Fort Peck Dam has five areas of proposed work totaling 12,810 feet affecting just over one-half percent of the river shoreline. The overall environmental effect of bank protection in this reach is considered to be insignificant.

23. As shown in Table E-1, the open river reach below Garrison Dam has 21 sites proposed in addition to the eight sites already constructed or under contract. The combination of proposed and completed works will affect approximately eight percent of the total bankline. This plan, in addition to protecting adjoining high bank land should diminish the rate of delta build-up in the headwaters of Lake Oahe. The overall direct environmental effect of the plan in this reach of the river is considered to be beneficial in that the unique and irreplaceable river valley woodland will be protected from eroding into the river. The indirect environmental effect, that of removing woodland and replacing this habitat type with cropland, is considered to be adverse. The reduction in the rate of build-up of the delta in the headwaters of Lake Oahe is considered to be an indirect beneficial effect.

24. Between Oahe Dam and Lake Sharpe, a distance of five miles, approximately two-thirds of a mile of shoreline adjoining the north end of Fort Pierre will be protected. The direct environmental effects of this action on the aquatic habitat is considered to be insignificant.

25. The open river reach between Fort Randall Dam and Lewis and Clark Lake has seven separate reaches of river bank identified as actively eroding. Two of these adjoin the Karl E. Mundt National Wildlife Refuge on the right bank at river miles 875 and 878. They are identified as Eagles Roost and Nine-mile Creek in Table E-1. According to recent studies of wintering eagles on and near the Refuge, as summarized on Figure E-1, mature cottonwood trees immediately adjacent to the river bank are among the sites favored

Figure E-1 DISTRIBUTION OF WINTERING BALD EAGLES



by the eagles; these trees are also most in danger of falling into the river, particularly in these reaches of active erosion. The U. S. Fish and Wildlife Service, however, has decided not to permit the actively eroding banks to be included in the plan for protection. Tree loss must, therefore, be expected to continue. The left bank protection structure in the vicinity of the fish spawning ground at the Nebraska-South Dakota state boundary will be designed so as not to adversely affect the spawning ground either due to increasing water currents beyond fish tolerances over the bed or by causing sediment deposition on the spawning bed. In all, about five percent of the river bank line will be affected by the plan. The overall, direct environmental effects of the plan for this reach of the river are considered to be beneficial. Since about 15 percent of the valley woodland in this reach is located on the river fringe, and this habitat type is most susceptible to conversion to cropland, the indirect, environmental effect of this potential conversion would be adverse.

26. Placement of structures totaling 130,000 linear feet is proposed for the river reach between Gavins Point Dam and Ponca State Park, the same reach of the river proposed for designation under the Wild and Scenic Rivers Act. This will affect 23 percent of the present bank line. The direct environmental effect of the construction of the protection structures and harvesting of the rock is not considered to be a significant adverse effect. Only structures now being installed under authority of Section 32 of the Water Resources Act of 1974, or modifications thereof, that demonstrate aesthetic and biological effects compatible with National Wild and Scenic River designation will be used in this river reach. Further, special effort in the design and placement of the structures will insure that the within-high-bank river features found to have outstandingly remarkable value in the wild and scenic river study fully described later in this Section will be preserved to the extent protective structures can accomplish the task. Thus, any direct environmental effects of these compatible structures are considered to be an acceptable trade-off for gaining protection of the riverine resources.

Because the Wild and Scenic River designation proposal incorporates about 1,700 acres of scenic easement of the high bank land in this river reach which will restrict timber removal, the opportunity for land owners to convert a significant amount of river fringe woodland to cropland will not exist. Hence, the indirect environmental effect of such a conversion is avoided.

Other Effects

27. The transfer of land use from woodland and pasture to cultivation has already been discussed in paragraph E-17. Other than the environmental impacts described there, and the accomplishments quantified in paragraph E-13, only minor effects are anticipated. Perhaps ten unskilled workers will be permanently employed in maintenance work. Monetary impacts on hunting and trapping are considered to be insignificant. Construction roads leading to the river for placement of the works will cause some temporary loss of crop production, but even this will not occur at every site since some placement will be done from the river side.

Design

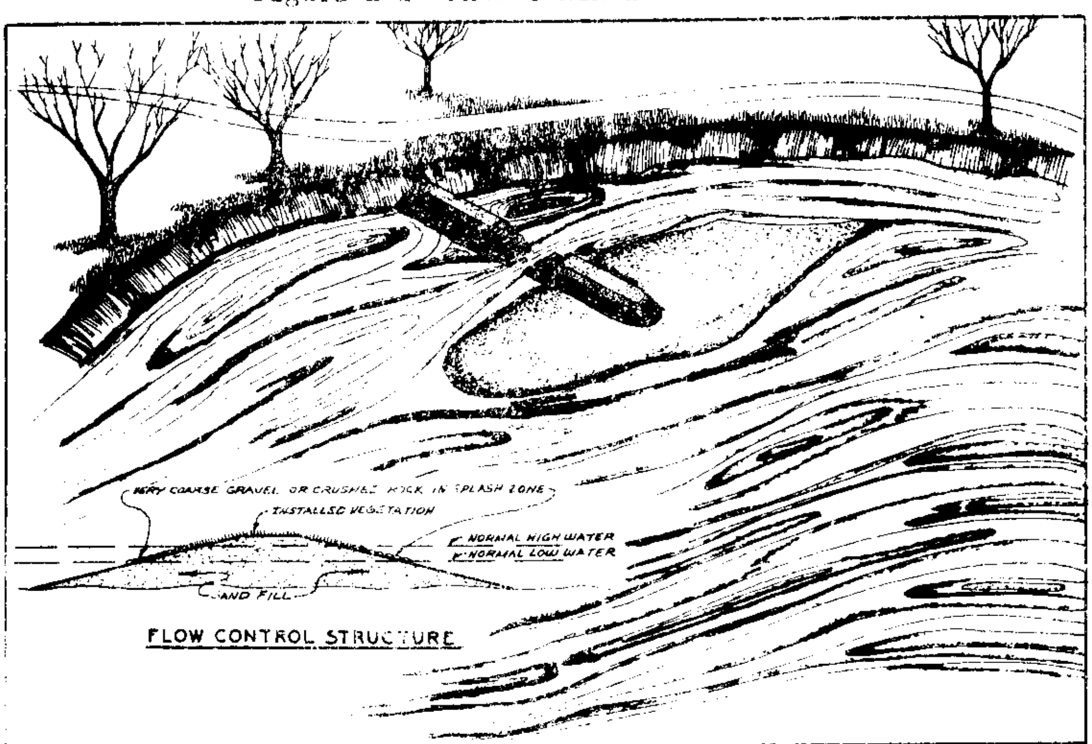
28. In accordance with the plan objective, a major design consideration will be to hold disturbance of bank and bar areas to a minimum to preserve a natural appearance. Suitability as fish habitat will be a primary criterion in the location and configuration of structures and selection of their construction materials. Critical technical factors affecting structure design and stability are bedscour at the toe of the bank, weathering in the zone of stage variation, ice action, and filtering of fine river sand through the structure. Velocity, per se, is not an important consideration in designing Missouri River structures; neither is the threat that design stages will be exceeded and the works damaged by frequent overtopping. The river stages actually experienced will almost always remain below the top of existing high banks and will vary between fairly well definable limits. Several types of protection

techniques will be used as appropriate, either as single measures or in combination, together with a standard design for river access points.

FLOW CONTROL STRUCTURES: (Figure E-2)

29. These structures project roughly perpendicular to an eroding bankline, beginning from the bankline and projecting riverward to an existing sand bar or island. The structure consists of a sand core, protected with an erosion resistant facing throughout the wash zone, then continuing on across the top with locally adaptable vegetation. Openings through the structure are constructed at varying elevations and locations to permit selected amounts of flow to pass through the chute. The structures are particularly adaptable for stopping secondary chutes from becoming the main river channel, thus containing the main flow in its present location, preserving the local riverine environment and precluding the need for extensive future bank protection works. The structure will preserve existing open water areas and provide increased variability in water depths.

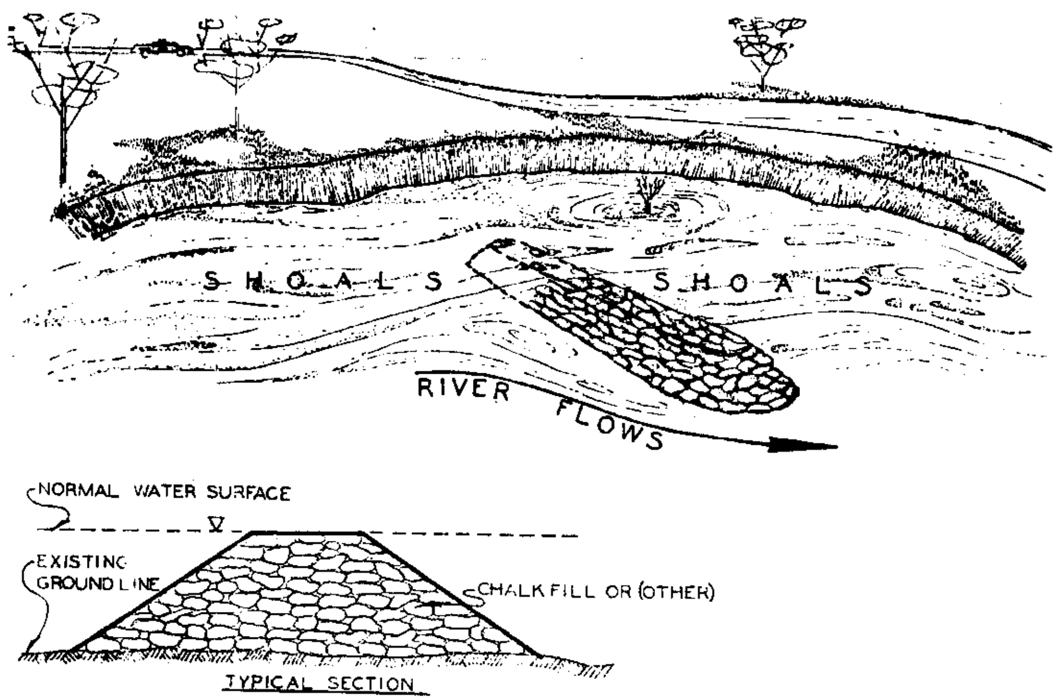
Figure E-2 FLOW CONTROL STRUCTURE



VANE DIKES: (Figure E-3)

30. Vane dikes are low elevation structures designed to direct the flow away from an eroding bankline. The structures would be constructed of rock or chalk the tops of which are constructed below the normal water surface, and would not be connected to the high bank. Water would be free to pass over these dikes but the main thread of flow would be directed away from the eroding bank. The structures will discourage high erosive velocities next to an unprotected bankline, thus encouraging diversity of channel depths, as well as protect existing natural bottomland characteristics.

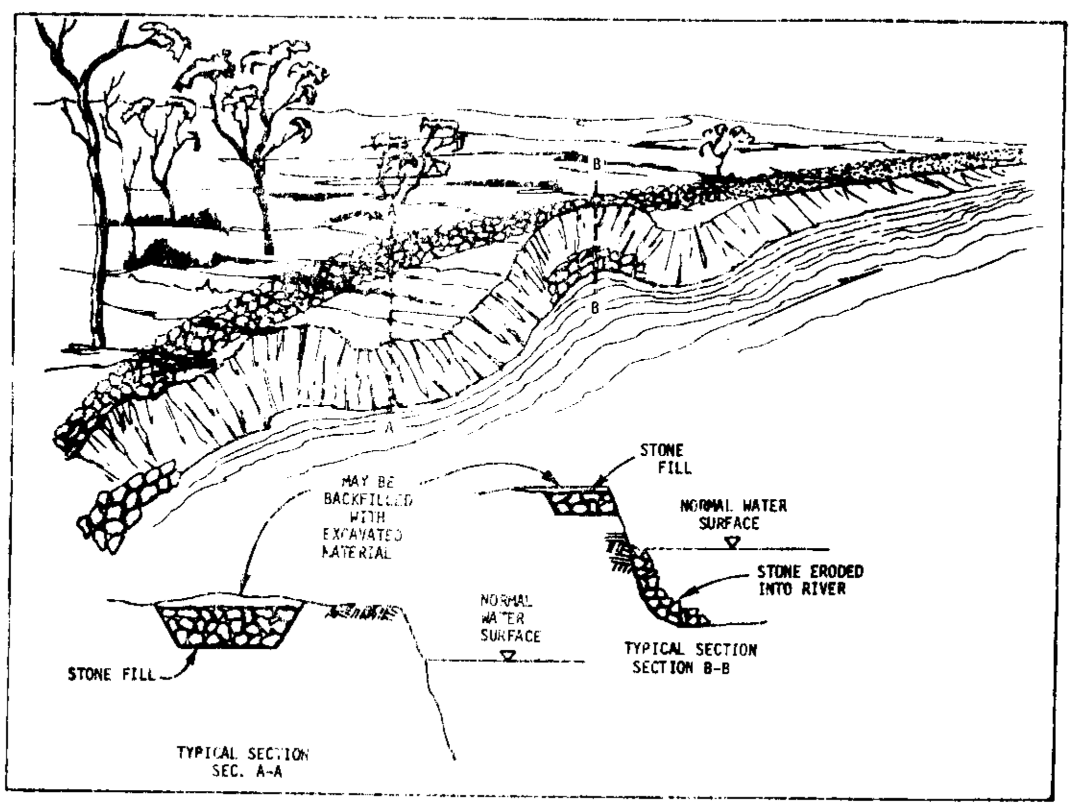
Figure E-3 VANE DIKES



WINDROW REVETMENT: (Figure E-4)

31. This control technique consists of depositing a fixed amount of erosion resistant material landward from the existing bankline, at a predetermined location beyond which additional erosion would not be permitted. The technique consists of burying a sufficient supply of erosion resistant material below the existing land surface, then permitting the area between the natural river bank and the buried windrow to erode through natural processes, until it reaches and undercuts the supply of rock. As the rock supply is undercut, it falls into the eroding area, thus giving protection against further undercutting, and eventually halting further landward movement. The resulting bankline would remain in a near natural state, with an irregular appearance with occasional scallops reaching backward to the windrow location. The treatment particularly lends itself to the protection of adjacent wooded areas, or next to long stretches of presently eroding irregular bankline.

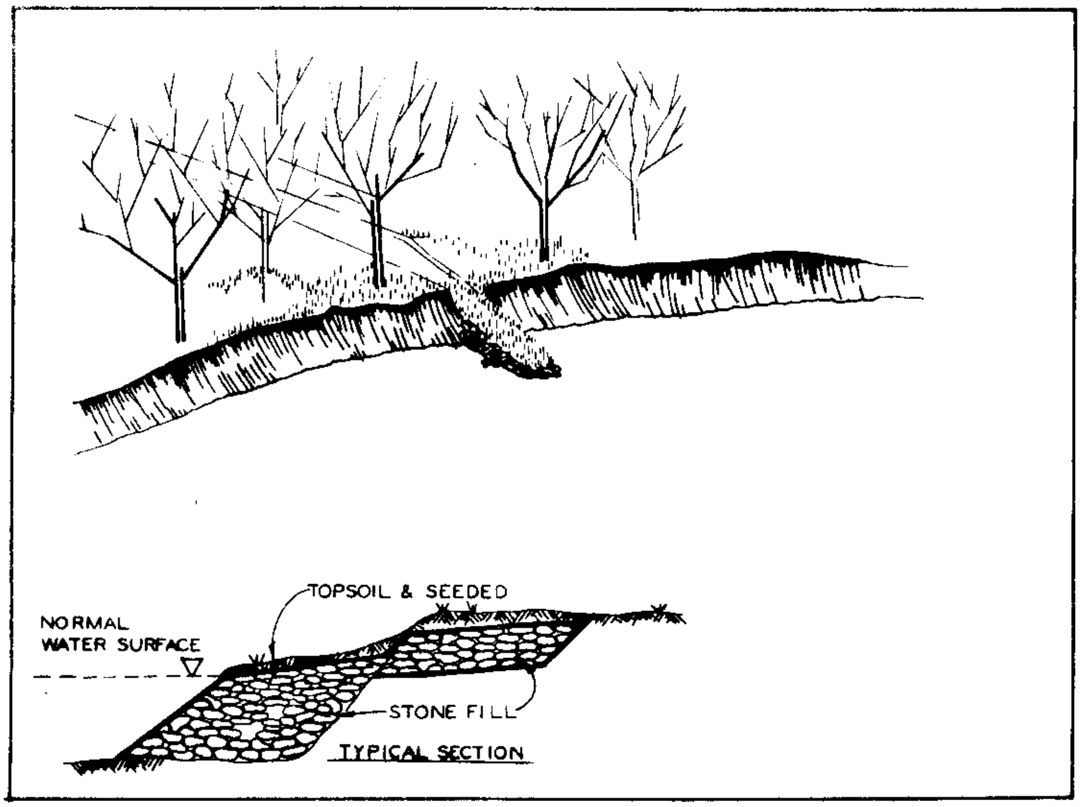
Figure E-4 WINDROW REVETMENT



ARTIFICIAL HARDPOINTS: (Figure E-5)

32. This management technique consists of sections of stone fill spaced intermittently along an eroding bankline. The structures protrude only short distances into the river channel and are supplemented with a root section extending landward to preclude flanking should excessive erosion persist. The majority of the structure cannot be seen as it consists of underwater placement or rock, covered with topsoil and seeded with a native vegetation. The structures are especially adaptable in long straight reaches not subject to direct attack.

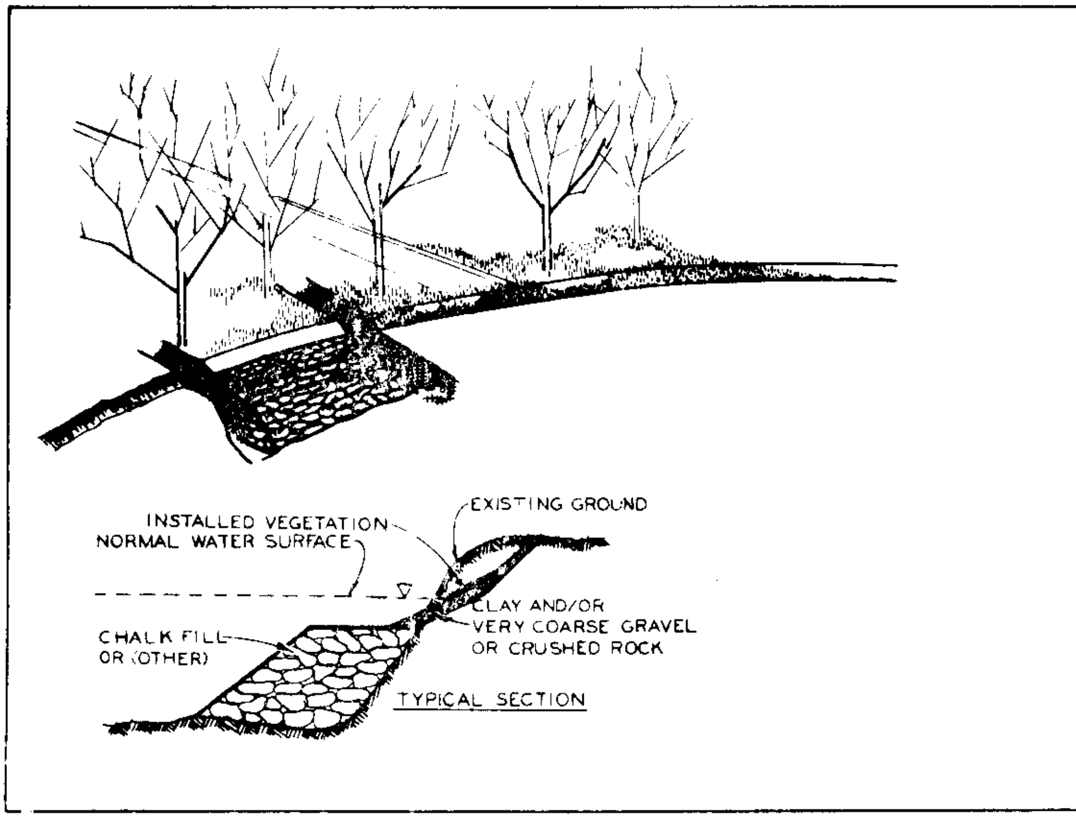
Figure E-5 ARTIFICIAL HARDPOINTS



COMPOSITE BANKLINE REVETMENT: (Figure E-6)

33. This technique will be used to control undercutting of an eroding bankline, and consists of protecting the lower underwater slope with sufficient materials, such as rock, sandbags, precast blocks, or plastic cloth, to prevent further erosive undercutting of the banks. The upper bank will receive a lesser treatment consisting of materials, such as compacted clay, coarse gravel, crushed rock, various vegetative treatments, plastic filter cloths, soil cement, or other materials to control erosion in the upper wash zone. In line with the environmental objectives of the plan, only minimal disturbance of the above-water portion of the bank will be permitted.

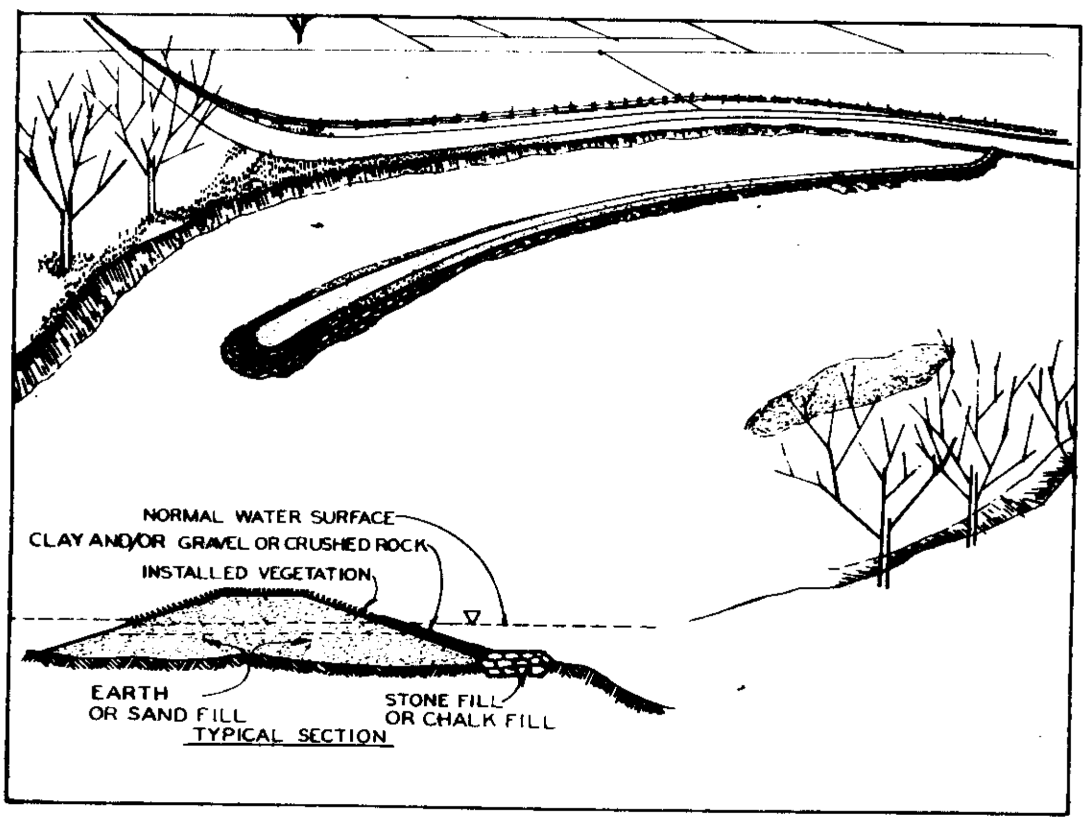
Figure E-6 COMPOSITE BANKLINE REVETMENT



SAND FILL REVETMENT: (Figure E-7)

34. This structure is used to redirect the main component of flow away from an eroding bankline, and is usually oriented roughly parallel to the existing bankline. The structure is attached to the bank at the landward end, and constructed of readily available materials such as sand, faced with a non-erodible layer of clay, gravel, or rock. Pipes at varying elevations would be installed at critical locations to permit small amounts of fresh water to enter the area between the structure and the original bankline. This area will become a slow-moving backwater area, open to the main flow at the downstream end. The structure would primarily be used to redirect the flow away from an eroding bankline, and at the same time reduce or eliminate the need for extensive protective measures farther downstream.

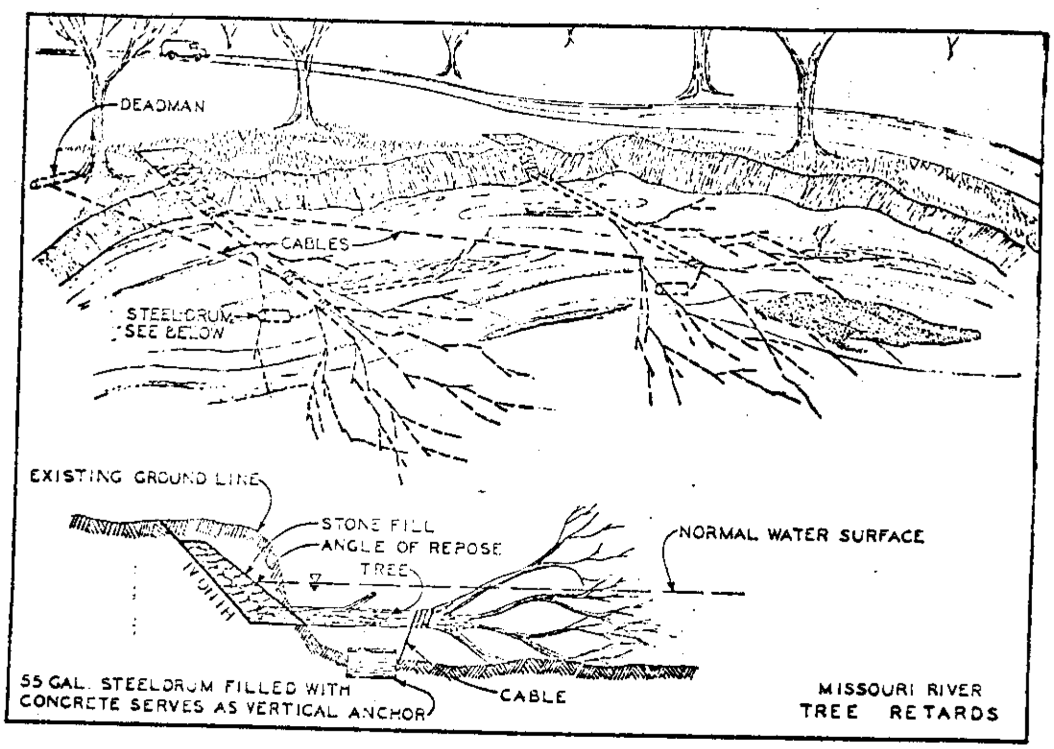
Figure E-7 SAND FILL REVETMENT



TREE RETARDS

35. This erosion control technique consists of 30 to 40 foot trees placed horizontally in the river perpendicular to the river bank. A small stone root and deadman will anchor the tree in the desired location. The branched portion of the trees will be resting on the bed of the river, thus screening the banks from direct river attack, encouraging the collection of debris, and reducing bank erosion. The technique is an attempt to reproduce a natural phenomenon that occurs throughout these river reaches where trees are undercut, fall into the stream, and form a natural barrier to further erosion. The bankline will remain in a near natural state, and provide excellent fish habitat.

Figure E-8 TREE RETARDS



RIVER ACCESS

36. Exclusive of the river reach below Gavins Point Dam which is discussed elsewhere in this report, river access points will consist of a single lane boat ramp and boat dock, gravel parking area, sanitary facilities and all weather, gravel access road from the nearest public, all weather road. Each site will require five acres to accommodate facilities development and public use and 66 foot width right-of-way for the access road. Average length of access is estimated to be one-quarter mile, making the total land requirement for each access an average of 7.5 acres.

Construction

37. It is estimated that the initial construction phase of the bank protection plan could be completed in all reaches in five years following receipt of construction funds. As stated previously, the areas of construction presented on Plates E-1 through E-35 are those considered most urgent at this time; priority and exact location of the works will be determined just before installation in order to insure maximum effectiveness. Construction techniques will vary at the various sites between placement by land or by floating plant depending on construction practicability, environmental impact or local site conditions and land use.

Operation and Maintenance

38. Description of the bank erosion process, the program recommended to reduce its effects, and the sponsorship requirements all point up the dichotomy to be found in responsibility for maintenance. On one hand, there exists a statutory responsibility for local assumption of the maintenance effort once construction is complete; on the other hand, the very process of completion as discussed in paragraph E-7 calls for on-going activity in response to changing river conditions over the years which is closely allied to new construction. In the past, local entities have expressed reluctance to sponsor stabilization works they might be unable to afford. It

is important that a clear demarkation be fixed between those continuing measures the Federal Government will undertake and those which must be undertaken locally.

39. Two aspects of this project extend the period of Federal responsibility beyond the end of initial construction:

- The nature of the program, "demonstration and evaluation", calls for innovative and unproven techniques. It is not reasonable to suppose their remedy lies within the limit of local resources.
- Since the accomplishment of an effective yet efficient plan depends on initial protection of presently evident "hot spots" with subsequent monitoring, identification, and annual treatment of new problem areas until bank erosion in the reach has been reduced to a tolerable minimum, both the initial construction and the annual treatment are considered here as properly accomplished by Federal effort.

40. Paragraph D-165 described existing policy applicable to Section 32 projects, which called for rehabilitation after five years of demonstration and evaluation. Continuation of this policy seems appropriate in the case of individual structures and reach segments after construction is fully complete. The best estimate, based upon past experience with bank protection works along the Missouri River main stem, is that twenty years of Federal treatment in the newly occuring areas of erosion will result in a well-stabilized section ready for local assumption of operation and maintenance responsibility. Federal costs for annual maintenance necessary for rehabilitation of existing structures, and the installation of additional works as required over a 20-year period after construction in a given reach, are estimated at five percent of the initial construction cost. After local takeover, annual maintenance costs are estimated to run one percent of construction cost.

Construction and Maintenance Costs

41. The Congressional actions which removed bank protective measures from the requirement for evaluation under Principles and Standards criteria have already been discussed. In the absence of this formulation methodology, compliance with the format of Section F, Economics of the Selected Plan, becomes moot. Cost estimates for placement and maintenance of the work listed in Table E-1 have been prepared, however, and are presented in the following paragraphs. Unit prices reflect 1976 contract bid experience.

CONSTRUCTION COSTS

42. Federal construction costs for protection of the areas shown in Table E-1 are presented in Table E-2. Not all of these costs, however, are newly created as a result of recommendations contained in this report. Some are costs authorized under Section 161 of the 1976 Water Resources Development Act for construction of specific works in the reach between Garrison Dam and Lake Oahe. Of the total $8,101,000 shown in Table E-2, $400,000 is a recommendation for new authorization; the remaining $7,701,000 is for work in compliance with Section 161. For orderly implementation of the recommendations in this report, it is necessary that all components of Table E-2 be incorporated into the normal budgeting process.

43. The non-Federal component of construction cost arises from the provision of lands, easements and rights-of-way. Permanent easements have been costed for the lineal feet of bankline protected and for a distance of 100 feet back from the river. The acreage thus developed together with other data used in estimating non-Federal construction costs are shown in Table E-3.

44. The unit cost of river access sites proposed in paragraph E-36 is estimated to be $49,200 not including land costs which are estimated to average $4,300 per site. Including indirect costs of 35 percent, each of the five sites has a construction cost of $71,000 distributed $213,000 in North Dakota and $142,000 in Nebraska.

Table E-2 MISSOURI RIVER BANK PROTECTION ESTIMATE OF FEDERAL CONSTRUCTION COSTS

River Reach Downstream of	Revetments 1/			Hardpoints			Flow Control Structure			Vane Dikes			Total Cost 3/
	Structure Length (L.F.)	Unit Cost	Subtotal	Structure Length (L.F.)	Unit Cost	Subtotal	Structure Length (L.F.)	Unit Cost	Subtotal	Structure Length (L.F.)	Unit Cost	Subtotal	
Fort Peck Dam	12,410	$90/LF	$1,117,000	--	--	--	--	--	--	400	$50/LF	$20,000	$1,137,000
Garrison Dam	55,800	$60/LF	$3,348,000	30,100	$70/LF	$2,107,000	4,350	$76/LF	$131,000	--	--	--	$5,786,000
Oahe Dam	3,050	$70/LF	$ 220,000	--	--	--	200	$91/LF	$ 18,000	--	--	--	$ 238,000
Ft. Randall Dam	8,870	$76/LF	$ 674,000 2/	1,000	$94/LF	$ 94,000	--	--	--	--	--	--	$ 768,000
Gavins Point Dam	85,387	$61/LF	$5,209,000	23,895	$75/LF	$1,792,000	16,200	$82/LF	$1,328,000	3,510	$50/LF	$176,000	$8,505,000
Total													
Construction			$10,568,000			$3,993,000			$1,677,000			$196,000	$16,434,000
E&D, S&A (12%)			1,268,000			479,000			201,000			24,000	1,972,000
Contingencies (25%)			2,959,000			1,118,000			470,000			55,000	4,602,000
Grand Total			$14,795,000			$5,590,000			$2,348,000			$275,000	$23,008,000

1/ Includes composite, sandfill, windrow, and tree retards
2/ Omits cost of 7,680 linear feet of intermittent composite revetment abutting Karl E. Mundt National Wildlife Refuge ($584,000)
3/ Reach totals including E&D, S&A, and contingencies are: Fort Peck, $1,592,000; Garrison, $8,101,000; Oahe, $333,000; Fort Randall, $1,075,000; Gavins Point, $11,907,000

Table E-3 MISSOURI RIVER BANK PROTECTION ESTIMATE OF NON-FEDERAL CONSTRUCTION COSTS

Item	River Reach					
	Downstream of Fort Peck	Downstream of Garrison	Downstream of Oahe	Downstream of Fort Randall	Downstream of Gavins Point	Total
Permanent Easement						
Acres	44	518	13	66	647	
Value/Acre	$ 335	$ 400	$ 425	$ 425	$ 640	
Cost	14,700	207,200	5,500	28,000	414,100	$669,500
Construction Access 1/	1,500	20,700	600	2,800	41,400	67,000
Administrative Cost for Acquisition	5,800	68,400	3,500	17,500	170,800	266,000
Contingencies @ 20%	4,400	59,300	1,900	9,700	125,300	200,600
Total	26,400	355,600	11,500	58,000	751,600	1,203,100

1/ Estimated at 10% of the cost of permanent easement.

MAINTENANCE COSTS

45. The transition from Federal to non-Federal maintenance of protective structures as discussed in Paragraph E-40 is shown in Table E-4. Operation and maintenance costs for the five river access points are estimated at $2,400 per year, per site, to be borne entirely by the local sponsors.

Table E-4 MAINTENANCE COSTS FOR BANK PROTECTION

Year	Constr. Placed by 1st of Yr	Fed Maint @ 5% of Constr	Constr. Assumed By Sponsor	Non-Fed Maint @ 1% Of Constr.	Total Maint
1	0	0	0	0	0
2	4,601,600	230,100	0	0	230,100
3	9,203,200	460,100	0	0	460,100
4	13,804,800	690,200	0	0	690,200
5	18,406,400	920,300	0	0	920,300
6	23,008,000	1,150,400	4,601,600	46,000	1,196,400
7	0	1,150,400	9,203,200	92,000	1,242,400
8	0	1,150,400	13,804,800	138,000	1,288,400
9	0	1,150,400	18,406,400	184,100	1,334,500
10-21	0	1,150,400	23,008,000	230,100	1,380,500
22	0	920,300	0	230,100	1,150,400
23	0	690,200	0	230,100	920,300
24	0	460,100	0	230,100	690,200
25	0	230,100	0	230,100	460,200
26-50	0	0	0	230,100	230,100
Avg Ann Equiv @ 6-3/8%		713,100		146,100	859,100

Hydro-Power

46. The selected plan consists of the addition of five new generating units to the main stem dam system on the Missouri River to increase the installed capacity by 457 megawatts and the development

of a pumped-storage facility adjacent to Lake Francis Case to provide 1,180 megawatts of peaking capacity. Because of the close association between design and operation and the environmental effects of the plan, discussion of those effects is removed in this discussion from its normal sequence so that the stage may be properly set.

Plan Description

47. The primary components of the hydro-power addition consist of:

- A new two-unit powerhouse adjacent to the existing two powerhouses at the Fort Peck Project, Montana, together with appurtenant features and including a reregulation dam and reservoir eight miles downstream from the new powerhouse. Each of the two existing flood control tunnels would be modified to accommodate a turbine-generator unit with a nameplate capacity of 92.5 megawatts for a total additional installed capacity of 185 megawatts. The aggregate capacity at the Fort Peck Project with the addition would be 350 megawatts. The new powerplant would also include miscellaneous accessory equipment, switchyard expansion, and tailrace. The hydraulic capacity of the Fort Peck Project powerplant would be increased to 32,600 cubic feet per second.

- A westward extension of the existing Garrison Project, North Dakota, powerhouse to include two modified flood control tunnels which would accommodate one 80-megawatt turbine-generating unit each and one modified flood control tunnel which would accommodate one 112-megawatt turbine-generating unit. Included in the plan is a reregulation dam and reservoir about 10 miles downstream from Garrison Dam. The Garrison Project aggregate power capacity would be increased to 672 megawatts with the 272-megawatt plant addition. The powerplant addition would also include miscellaneous accessory equipment, and a southward extension of the existing switchyard. The hydraulic capacity of the Garrison Project powerplant would be increased to 70,300 cubic feet per second.

- A 1,180-megawatt pumped-storage powerplant adjacent to Lake Francis Case, located about three miles south of the Platte-Winner bridge in Gregory County, South Dakota. The pumped-storage facility would consist of a leveed-forebay with an active storage capacity of 46,800 acre-feet; a 1.6-mile long, 30-foot diameter, underground power conduit; a powerhouse with three 394-megawatt reversible pump-turbine units; and a 3,000-foot long trapezoidal-shaped tailrace section. The project would develop an average gross head of 711 feet for peaking capacity. Utilization of the reversible turbines to lift water for municipal and agricultural use to the forebay for ultimate distribution to towns and farms in and near Gregory County could be included as an ancillary function of the project. Perhaps one-half percent of the active forebay storage would be required to meet potential daily irrigation and municipal needs. The forebay operating range would be 61 feet per week and the afterbay (Lake Francis Case) operating range would seldom exceed 30 feet per year. Maximum discharge during generation periods would be 24,740 cubic feet per second and pumpback discharge would be 16,490 cubic feet per second. The forebay levee would be about 49 feet in average height and 30,100 feet in length. The water surface area of the forebay would be 1,155 acres.

48. Plates showing the location, layout and other pertinent data are referenced by project in the section on design of hydro-power facilities.

Evaluated Accomplishments

49. In addition to an excess of benefits over costs in the ratio of 1.6 to 1, as detailed in Section F, the plan also:

- Contributes to the national economy in the amount of $68,000,000 a year as measured by the alternative cost of generation.
- Adds 1,637 megawatts to the installed capacity in the region served by MARCA, thereby satisfying four percent of the increase estimated to be necessary by 1994.
- Increases efficiency in use of thermal resources by **obviating** oil-fired turbines, permitting substitution of base-loaded plants using less scarce and costly coal and lignite.

● Affords the potential to lift water 700 feet for consumptive use in the plateau area adjacent to Lake Francis Case.

Other Effects

50. Aside from environmental effects, the identified consequences of this plan element over and above its intended accomplishments involve employment, recreation and water intakes. The selected plan will not significantly affect hunting or trapping.

REGIONAL EMPLOYMENT

51. An estimated 1,810 persons will be directly employed during the construction period, requiring expansion of existing community facilities. About 60 permanent workers in semi-skilled jobs will be added in areas which have experienced chronically high unemployment.

PRIME OR UNIQUE FARM LAND

52. As measured by total dollars expended, land conversions from existing uses to Federal management comprise a very small portion of the recommended hydro-power plan. Nonetheless, some acquisitions of private land will be necessary.

● 1,650 acres at Gregory County for operational purposes.

● 2,305 acres at Garrison for operational purposes.

● 270 acres at Garrison for mitigation of 180 acres of terrestrial habitat inundated by the reregulation pool.

● 1,290 acres at Fort Peck for operational purposes.

● 480 acres at Fort Peck for mitigation of 200 acres of terrestrial habitat to be inundated by the reregulation pool.

53. In response to a Criteria Memorandum of 30 August 1976 issued by the Council on Environmental Quality, it was necessary to ascertain whether any of the proposed land acquisition falls into the category of "prime or unique," farmland. Telephone consultations

were held with U. S. Department of Agriculture offices at Huron, South Dakota, Bismarck, North Dakota and Wolf Point, Montana; the consensus was that lands considered for this plan do not fall within the intent of the 30 August memorandum.

RECREATION DOWNSTREAM OF FORT PECK

54. About 48,000 existing recreation days would be directly affected by the Fort Peck reregulation reservoir; however, about 80 percent or about 38,000 recreation days can be retained by proposed recreation redevelopment, consisting of boat ramp and access facility replacement. The remaining 10,000 recreation days are presumed to occur at alternative locations due to the changed conditions. New visitation would very likely be generated by the reregulated stream and redevelopment facilities and these losses could be offset by this new visitation. Insufficient data on recreational use along open river reaches preclude an analysis of the effect regulated flows would have on existing visitation; however, the recreational attractiveness of the open river reach should increase since flows will be regulated.

RECREATION DOWNSTREAM OF GARRISON

55. About 141,000 recreation days will be affected by the Garrison reregulation reservoir. About 90 percent or 127,000 are considered retainable as project visitation through facility redevelopment below the reregulation dam. Ten percent are presumed to occur at alternative locations due to changed conditions. New visitation may develop due to the regulated stream and the redevelopment facilities. An increase in visitation to the neighboring Knife River Indian Villages National Historic Site may occur after recreation redevelopment. The presence of the National Historic Site will significantly complement the new downstream recreation opportunities.

WATER INTAKES

56. In the 190-mile reach between Fort Peck Dam and the headwaters

of Lake Sakakawea there are 108 pumps or pump sites intended for obtaining water from the Missouri River. Irrigation of individual farms account for 92 of the units, one is for industrial supply and 15 are for domestic supply. Of these, the one industrial user, ten irrigation users and six domestic users will be within the 8-mile reregulation reservoir reach. Detailed studies during the design phase would be undertaken to determine a site by site evaluation of the individual intake requirements and the necessary remedial measures, if any, that should be implemented. Improvement of river flows downstream over existing conditions should result from regulation or operations, thus benefiting all or most of the remaining 91 pump sites.

57. In the 83-mile reach from Garrison Dam to the headwaters of Lake Oahe there are 37 pumps or pump sites intended for taking water from the Missouri River. Irrigation of individual farms accounts for 28 of the units, five are industrial water supply, three are for municipal supply and one serves an organized irrigation district. Of these, only one user, an irrigation pump site, would be within the 10-mile Garrison reregulation reservoir reach. Remedial measures, if any, and the extent individual sites are affected would be determined during the detailed design phase.

Design

58. This section contains information on the hydro-power facilities themselves, on relocations and rights-of-way, on foundation conditions, and on mitigation requirements.

59. A design consideration even more important than installed capacity in assessing the accomplishments of a hydro-plant, including its very feasibility, is the dependable capacity - which the Federal Power Commission has defined as the load-carrying ability of a station or system under adverse conditions. Paragraphs B-99 and B-100 identify this adverse condition for the main stem system as August of 1933. Reservoir elevations which were developed in a series of system operation studies and printed in MRD Publication - Main Stem

Reservoir Regulation Studies, Series I-74 were used in determining the dependable capacities at Fort Peck and Garrison which are given in table E-5 and E-6. A different procedure applies at Gregory County; it is described under Gregory County.

HYDRO-POWER FACILITIES - FORT PECK

60. The original construction of Fort Peck included four flood control tunnels with intakes located in the right abutment about 2,000 feet upstream of the axis of the dam. Main control shafts had two concentric conduits, so that water from the intake tunnel flowed upwatd in the outer tunnel, through ports in the cylinder gates and down the inner conduit to the discharge tunnel. Tunnels one and two have already been modified by removing the inner shaft and now serve the two existing power plants. Similar modifications will be made to Tunnels three and four, which will then serve Powerhouse No. 3. Peak discharge through each tunnel will be about 8,700 cfs. Sverdrup and Parcel's 1973 report found that surge tanks on the additional units are not needed if governor times are held to 60 seconds and the units are base-loaded, leaving Powerplants one and two to swing with the load.

61. As shown on Plate E-36, Powerhouse No. three will be located about 200 feet northwest of Powerhouse No. two, which is unable to accommodate the new units due to lack of space and soil stability problems which make excavation risky. In addition to accommodating Tunnels three and four extended to permit proper alinement and spacing of two Francis turbines, the new powerhouse will contain miscellaneous accessory equipment, a 230 KV switchyard expansion and a tailrace, all shown on Plate E-37. The new powerplant will be operated from the control room in Powerplant No. One. Pertinent hydraulic and hydroelectric data are summarized in Table E-5.

62. The reregulation structure and its upstream pond, shown on Plate E-38, were designed to minimize discharge variation in the river downstream during operation of Fort Peck as a peaking plant. The weekly discharge pattern which contributes most to meeting the region's peak

load is one of full output to the extent permitted by the water supply with a shutdown to zero during the remaining off-peak hours. To achieve complete regulation it would be necessary to have enough storage available between the reregulation structure and Fort Peck Dam to maintain a uniform downstream discharge during the longest period of zero powerplant release which would occur during any weekly cycle.

TABLE E-5 PERTINENT DATA ADDITIONAL HYDRO-POWER AT FORT PECK

Item	Description	Item	Description
Critical Head-Net avg	148'		
Head Losses (approx)	20'	Full Gate Discharge	
Critical Head-Gross	168'	Existing	15,200 cfs
Full Gate Tailwater	2040' msl	With Additions	32,600 cfs
Critical Elevation	2208' msl	Installed Capacity	
Aug 1933 Elevation 1/	2221' msl	Existing	165 mw
Tunnels converted	2	With Additions	350 mw
Converted diameter	22'8"	Dependable Capacity	
Additional Turbines	2 Francis	Existing	184 mw
Additional Generators	2@92.5 mw	With Additions	380 mw

1/ Elevation which determines dependable capacity

63. Since there are physical limitations on the volume of reregulation storage available, something less than complete reregulation must be accepted for some peaking schedules. On the other hand, an abundant water supply necessitates discharge during off-peak hours, making a five-day generating schedule unnecessary. Conditions limiting the available reregulation storage are:

- The maximum water surface elevation which will not cause undue flooding in the eight-mile storage reach.
- Allowable reduction in power head due to high tailwater elevation.

64. The normal tailwater for 32,600 cfs at the dam is 2039.0 feet msl and this elevation is also about 1.0 foot below the average flooding elevation for the adjoining lowland, hence it was assumed to be the maximum ponding elevation. At this elevation there are approximately 20,000 acre-feet of storage available for reregulation.

65. Either vertical lift gates or tainter gates appear feasible for the regulation structure; final selection will be made in post-authorization studies. Automated gate operation with continuous sensing of the pool and tailwater levels will be employed to maintain uniform discharges throughout the range of changing water levels. The gate sills will be placed at the riverbed elevation to afford maximum utilization of available storage. Gate guides and walkways would extend above maximum flood elevations so gates could be raised above the expected flood crest to reduce the hydrostatic overturning forces on the structure. Figure E-9 shows the general arrangement of vertical lift gates for the Fort Peck reregulation structure.

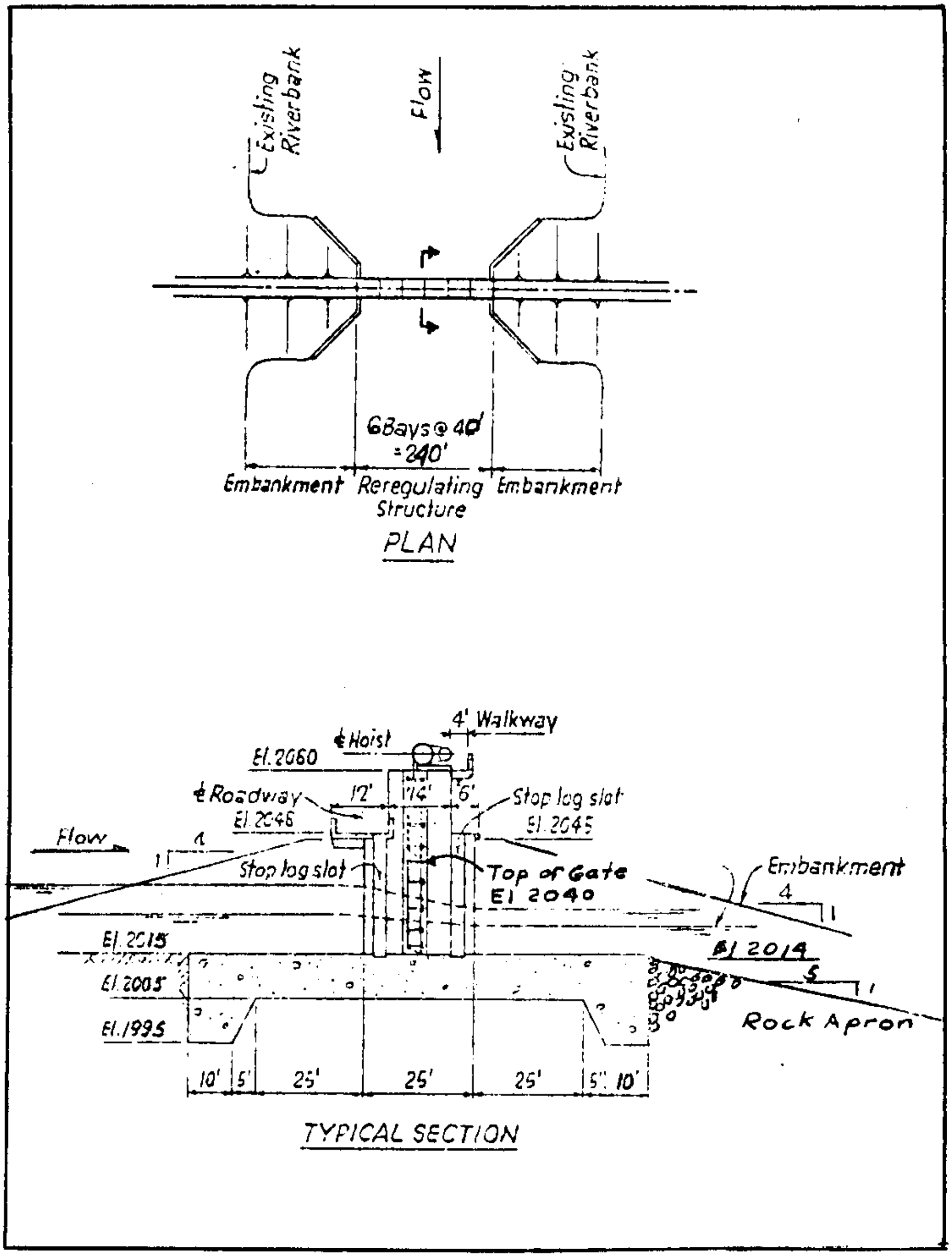
RELOCATIONS, MODIFICATIONS AND RIGHTS-OF-WAY - FORT PECK

66. Construction of the reregulation dam approximately eight miles downstream will require the purchase of 1,290 acres now in private ownership and removal of two farm buildings. An additional 480 acres are recommended for acquisition to mitigate wildlife habitat inundated by the reregulation pool. Relocation of the tailrace recreation facilities downstream to Federal lands in the reregulation dam tailrace can be accomplished without acquisition of additional land; no road relocations are anticipated.

FOUNDATION CONDITIONS - FORT PECK

67. Paragraph D-148 identified the existence of stability problems at Fort Peck; they created considerable difficulty during construction of Powerhouse No. 2. Soldier beams were installed, then small cells were excavated and cross-braced; construction in one cell was

Figure E-9 FLOW CONTROL STRUCTURE - FORT PECK REREGULATION DAM



built back before adjacent cells were excavated. Even with these precautions, some slides developed. Excavation for the recommended two-unit plan must accommodate a slab elevation of 1977 msl, 19 feet below that for Powerhouse No. 2. An alternative design in Sverdrup and Parcel's 1973 report requires excavation only to a depth of 1991. This is accomplished by installing two small turbines per tunnel rather than a single larger unit.

68. Prior to detailed study of the geological conditions, it has been assumed that as a minimum the four-unit scheme could be built utilizing restraints similar to those employed in the successful completion of Powerhouse No. 2. If the geology proves less favorable, some newer innovations may have to be adopted such as drilling-in large diameter piers surrounding the deeper areas of the draft tube; the sump might also have to be a drilled hole. Detailed study of various layouts and construction schemes will be necessary before a final choice is made between two-unit and four-unit design. Such study must include determining the change in the existing stresses with depth, the location of existing bentonite seams, slickensides, gouge zones, etc. Because these explorations have to be done in water and in an area of fluctuating tailwater, the program goes beyond survey report scope and is proposed for accomplishment during preparation of the Phase I Design Memorandum.

69. Although all of the detailed economic analyses made in this report are based on the two-unit concept, the four-unit design is economically feasible. Project cost would rise about ten percent and the benefit-cost-ratio would decline from the present 1.5 to become 1.4.

<u>MITIGATION - FORT PECK</u>

70. At Fort Peck, mitigation of fish and wildlife resources, and particularly habitat, will consist of restricting the adverse effect which reregulation pool fluctuations would have if transmitted to

the dredge cut lakes west of Highway 249; protecting Duck and Scout islands from damaging erosion from increased velocities; and compensating for inundation of more than 200 acres of terrestrial habitat. The reregulation reservoir itself is, of course, the most extensive and expensive mitigative measure of all.

71. About 643 acres of dredge cut will be isolated from the reregulation reservoir by a reinforced concrete box culvert with slide gate. The gated structure consists of a 150 foot 4 by 4 culvert with manual gate controls to allow regulation of water exchange between the dredge cuts and the reregulation reservoir. A portion of the existing opening under the Highway 249 bridge will be replaced with the 4 by 4 structure and appropriate earth fill. Whenever fresh water is required in the dredge cuts the gate will be opened while reregulation reservoir levels exceed the dredge cut level. Drainage of the cuts can be accomplished during low reregulation reservoir levels. Because of elimination of fish movement between the dredge cuts and the reregulation pool, fishery management of a self-sustaining population through chemical rehabilitation, stocking and prevention of rough fish passage will be investigated during design phases.

72. Scout and Duck islands are being used by wildlife. Continuing reregulation pool fluctuations coupled with water movement in the river channels adjacent to the islands could cause significant erosion of the islands. As shown on Plate E-39, this will be countered by placement of riprap at points of attack by high velocities. The unprotected banks of the islands will eventually adjust to a stabilized beach slope under the action of fluctuating water levels. Although an increase in the groundwater level on the islands will cause some changes in habitat type, such changes are not expected to be repellent to Canada geese, white-tailed deer and other wildlife species now using the islands.

73. More than 200 acres of terrestrial habitat, consisting of shrub

grassland, woodland, savannah, marsh and farmland will be inundated by the reregulation pool. These habitat types were identified and evaluated by a team of biologists which represented Montana, the U. S. Fish and Wildlife Service and the Corps of Engineers. In this report, however, the Corps of Engineers has not found farmland to be a limiting habitat type in the general area of the reregulation pool; consequently, mitigation of adversely affected terrestrial habitat will be limited to fee acquisition of woodland, shrub grassland and savannah downstream of the reregulation dam -- about 240 acres on the right bank and 240 acres on the left bank. These lands will be protected from cattle grazing by the use of fencing where necessary and the shrub grassland will be interseeded with native grass species to increase its value to wildlife. The amount of land recommended for terrestrial wildlife mitigation is based on the proposition that habitat type lands similar to those being inundated will be acquired, and that the lands' existing value will be significantly increased by outgrant of the land for management by the State and by development features being recommended.

74. Nesting platforms could be installed on Duck and Scout islands and on lands being acquired for the reregulation pool, should increased Canada goose production be desired by Montana and the Fish and Wildlife Service. The General Plan, which is an agreement between the Secretary of Army, Secretary of Interior and State wildlife agency, as specified by the Fish and Wildlife Coordination Act, will address the specifics of wildlife management.

75. Boating access to the dredge cut lakes will be prevented by the gated structure in the Highway 249 bridge site. To replace it another boat ramp, including road access, parking area, sanitary facilities, and boat dock will be provided at the dredge cut. Public use of the Fort Peck tailrace will be relocated to the reregulation tailrace. Boating access (interior roads, parking, sanitary facilities, ramp and docks) will be provided at the reregulation tailrace.

HYDRO-POWER FACILITIES - GARRISON

76. The outlet works at Garrison presently consists of a reinforced concrete intake structure at the upstream toe of the dam and three concrete-lined tunnels leading to the outlet stilling basin at the downstream toe of the dam. Conversion of these facilities to accommodate additional hydro-power units can be done by adding steel tunnel liners direct-embedded and backfilled with concrete. The embedded liner will transmit a portion of the hydrostatic force to the funnel wall, reducing the required steel thickness and resulting cost. Tunnels 7 and 8 will take 20-foot diameter liners and Tunnel 6 will take a 24-foot liner.

77. The three additional Francis turbines will be housed in a westward extension of the existing powerhouse. The location is shown on Plate 40 and the general layout on Plate 41. Rated capacity of Tunnel 6 will be 12,700 cfs; Tunnels 7 and 8 will discharge 8,800 cfs. As at Fort Peck, surge tanks are not proposed for the additional units; instead governor design will confine rapid load changes to the existing units. Pertinent hydraulic and hydroelectric data are summarized in Table E-6.

TABLE E-6 PERTINENT DATA ADDITIONAL HYDRO-POWER AT GARRISON

Item	Description	Item	Description
Critical Head-Net avg	131'		
Head Losses (approx)	15'	Full Gate Discharge	
Critical Head-Gross	146'	Existing	40,000 cfs
Full Gate Tailwater	1682' msl	With Additions	70,300 cfs
Critical Elevation	1828' msl	Installed Capacity	
Aug 1933 Elevation 1/	1815' msl	Existing	400 mw
Tunnels Converted	3	With Additions	672 mw
Converted Diameter	1@24' 2@20'	Dependable Capacity	
Additional Turbines	3 Francis	Existing	378 mw
Additional Generators	1@112mw 2@80mw	With Additions	598 mw

1/ Elevation which determines dependable capacity.

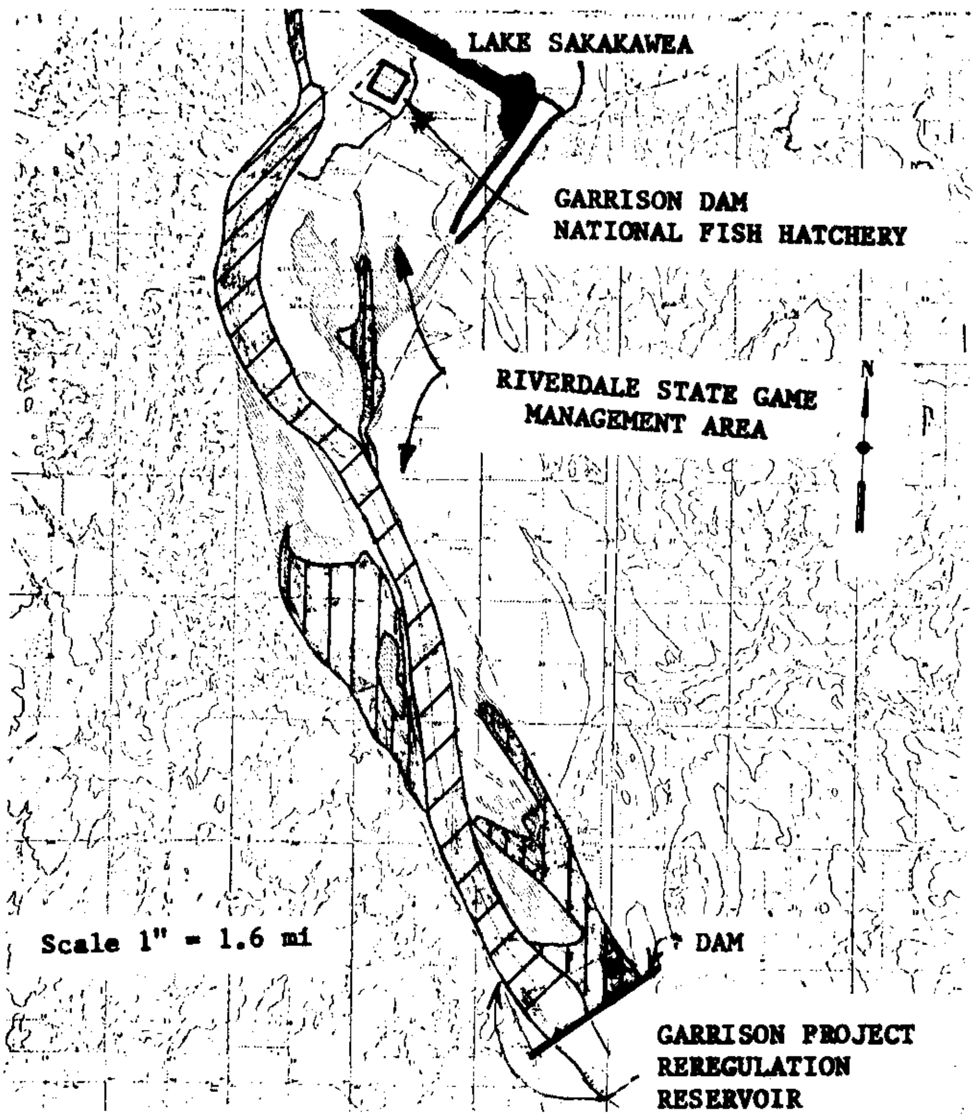
78. The reregulation structure and the attendant reservoir, shown on Figure E-10, were designed to minimize the discharge variation in the river downstream during peak power operations at Fort Peck. Unlike the Fort Peck reregulation structure, the volume of reregulation storage available and the high peak flows at Garrison precludes a weekly operation with reduced generation on week-ends. Rather, the Garrison reregulation structure is designed for daily operation. Conditions which limit available storage include the maximum water surface elevation which will not cause undue flooding in the ten-mile storage reach and allowable reduction in power head due to high tailwater stages. The approximate elevation - 1682 - was assumed as the limiting elevation for maximum ponding elevation. The gross storage available at this elevation is approximately 30,000 acre-feet.

79. Either vertical lift gates or tainter gates appear feasible for the reregulation structure. The final selection will be made in post authorization studies. Refer to paragraph E-67 for further information. Figure E-11 shows the general arrangement of vertical lift gates for the Garrison reregulation structure.

<u>RELOCATIONS, MODIFICATIONS AND RIGHTS-OF-WAY - GARRISON</u>

80. Construction of the reregulation dam about ten miles downstream will require the purchase of 2305 acres in private ownership. An additional 270 acres are recommended for acquisition to mitigate wildlife habitat inundated by the reregulation reservoir. An existing boat ramp in the reregulation reservoir area will be removed and a new ramp, including parking and sanitary facilities, will be constructed downstream of the reregulation dam without acquisition of additional land.

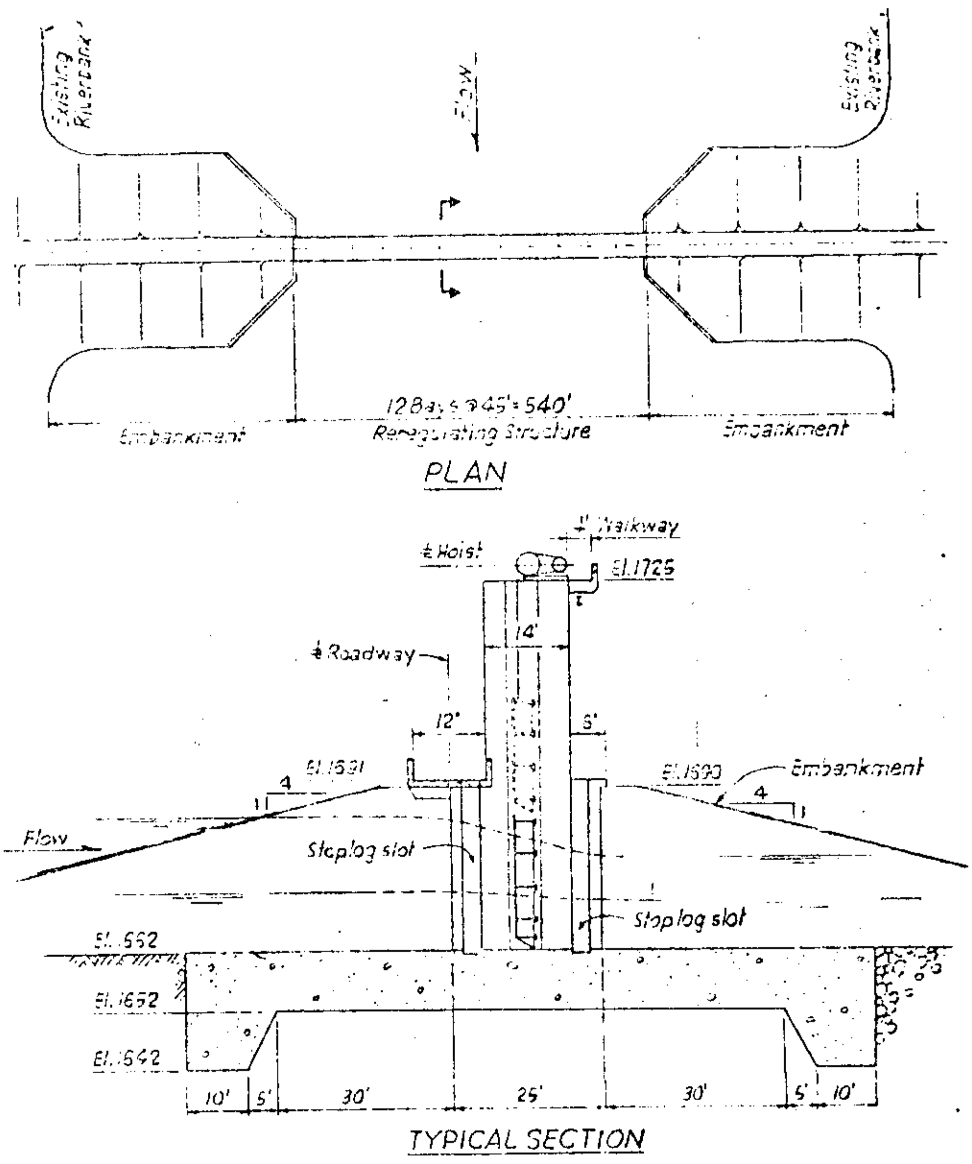
Figure E-10 GARRISON REREGULATION RESERVOIR



LEGEND

	Elevation msl	Symbol
Area of inundation	$\leq$ 1682	
Freeboard Zone	1682-1685	

Figure E-11 FLOW CONTROL STRUCTURE GARRISON REREGULATION DAM



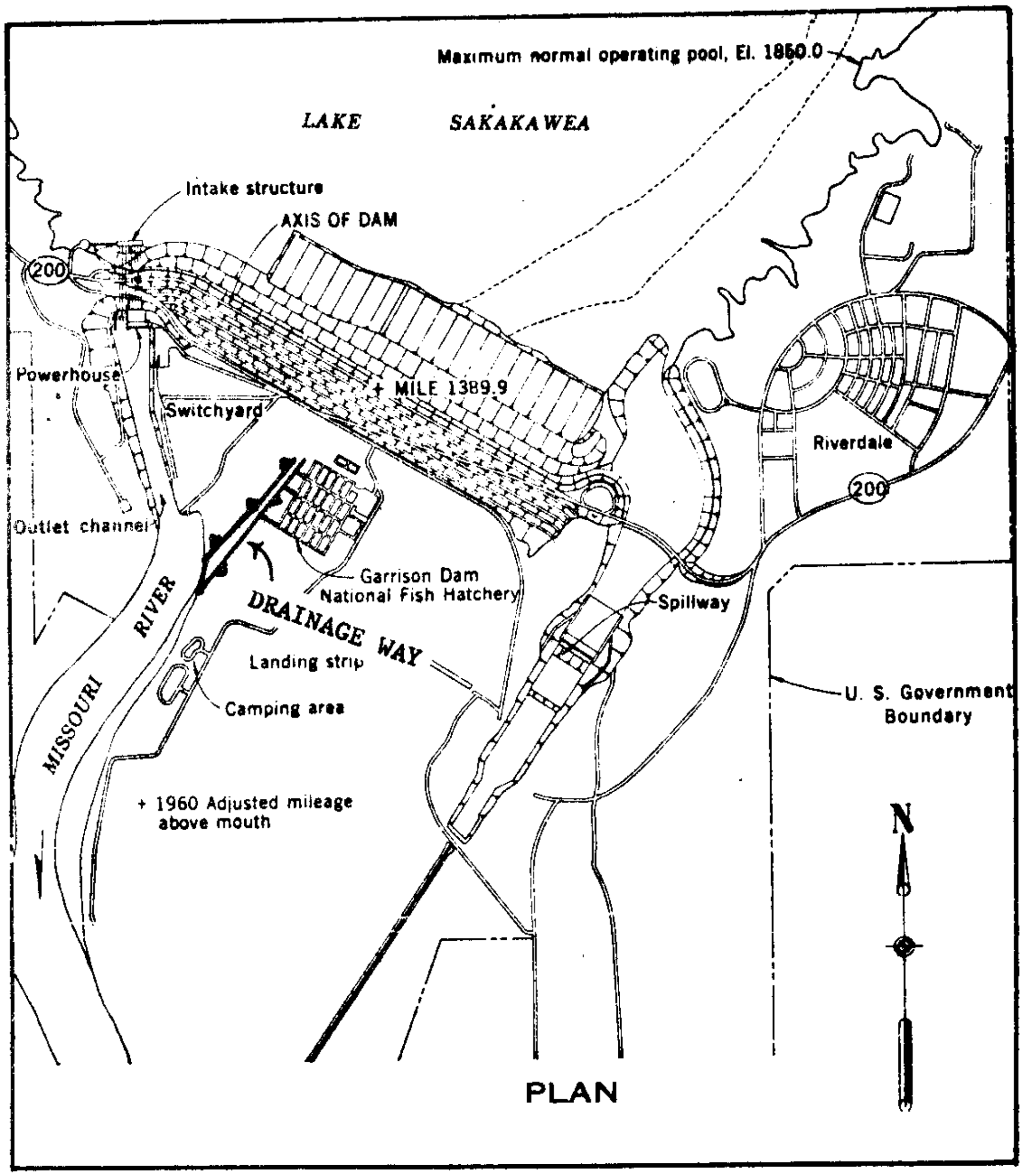
81. Garrison Dam National Fish Hatchery is located on the left bank immediately below the dam and adjacent to the tailrace as shown in Figure E-12. When filled or nearly filled, the reregulation reservoir would prevent the operation of emptying the rearing ponds unless remedial measures were taken. To do this, a drainage way and ponding area will be formed by placement of low earthen levees flanking the present drainage ditch which lies about 500 feet west of the hatchery.

82. About 3,000 feet of levee averaging about five feet high along each side of the drainage way are required, together with a corrugated metal pipe and flapgate at the entrance to the river. The flapgate will protect the existing lower catch basin drainage facilities with an invert elevation of 1680.3 from backflow when the pool elevation peaks at up to 1685 feet msl. The drainage way would provide sufficient storage for retention of catch basin flows for periods up to ten hours release. Whenever pool levels drop to less than 1680 feet msl the drainage way will automatically drain into the river. The low levee will be seeded to blend in with the surrounding landscape.

FOUNDATION CONDITIONS - GARRISON

83. The only issue to date has been the effect fluctuating stages may have on the water table in the vicinity of the fish hatchery. As stated in paragraph D-175, this analysis will be part of advanced design. Soil transmissivity tests to enable accurate predictions of ground water behavior in response to fluctuating pool elevations will be made during advanced design stages. Subsurface soil tests will be run during this period to determine specific foundation conditions in the vicinity of the reregulation dam site.

Figure E-12 FISH HATCHERY MODIFICATION - GARRISON DAM



MITIGATION - GARRISON

84. The reregulation structure at Garrison will confine the adverse effects of stage fluctuation to the reregulation pool. The reregulation reservoir will inundate approximately 180 acres consisting of sand bar, hardwood forest, savannah and open herbaceous areas. Another loss of approximately 20 acres will result from bank slope adjustment. These habitat types were identified and evaluated by a team of biologists which represented North Dakota, the U. S. Fish and Wildlife Service and the Corps of Engineers. In this report the Corps of Engineers has not found farmland or non-vegetated sand bars to be a limiting habitat type in the general area of the reregulation pool; consequently, mitigation of adversely affected habitat will be limited to fee acquisition of approximately 270 acres of habitat similar to that described above with the exception of farmland and non-vegetated sand bar. An existing boat ramp would be replaced with a new ramp constructed downstream from the structure along with sanitary facilities and parking facilities.

HYDRO-POWER FACILITIES - GREGORY COUNTY

85. Principal elements of the Gregory County Pumped-Storage Project consist of a forebay, power tunnel, powerhouse and discharge channel shown on the location map, Plate E-42. Forebay storage of 47,100 acre-feet of which all but 300 acre-feet is active lies within a levee 30,100 feet long and an average of 49 feet high. An impervious liner about three feet thick will prevent seepage out of the forebay bottom; alternatively, a slurry trench cutoff to impervious strata may be used depending upon further geologic exploration. The forebay levee has a 15-foot crown width, and side slopes of 1 on 3 for the top 30 feet of height flattening to 1 on 5 and 1 on 7 on the landward side as dictated by topography and 1 on 5 and 1 on 10 on the reservoir side. The reservoir side of the levee is lined with eight-inch bedding material and 20-inch riprap along the 1 on 3 side slope area while the 1 on 5 slopes are lined with eight-inch bedding and 17-inch riprap. An inclined vertical pervious drain and a horizontal

pervious drain permit collection and disposal of seepage flows through the structure. Material for the levee embankment will come from tailrace excavation and forebay collector channel excavation.

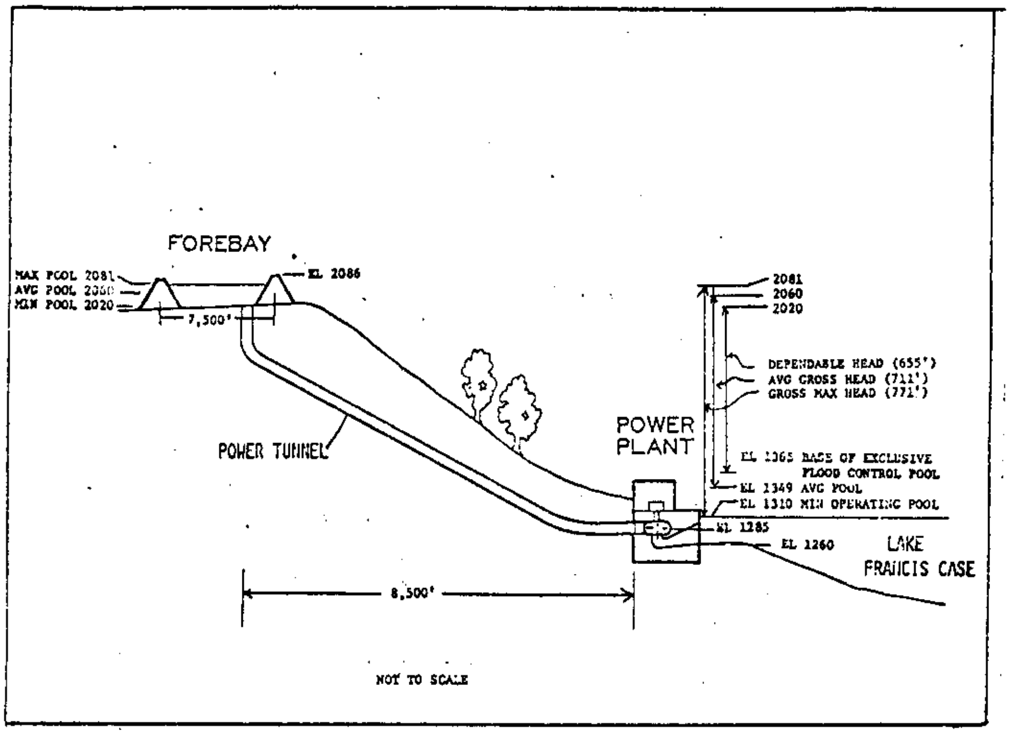
86. A collector channel directs flows to a cylindrical lift-gated intake in the forebay, as detailed on Plate E-43. From there, a 30-foot diameter steel-lined power tunnel, 8,500 feet long, leads to the power house and a manifold of three 17-foot tubes supplying three turbine generator-units rated at 393.3 megawatts each. Each can be reversed to serve as a motorized pump. Peak generating discharge is 24,700 cfs at a velocity of 35 feet per second; pumping capacity is 16,500 cfs. Plate E-44 presents plan and section views of the powerhouse. The afterbay discharge channel, shown on Plate E-45, is 3,000 feet long, with a bottom 120 feet wide and 20 feet below the minimum pool elevation of 1310 msl.

87. As shown on Figure E-13, the gross head available at the Gregory County site ranges from 771 feet (ignoring the two-foot effect of tailwater) when the forebay is full and Fort Randall is at minimum pool to 645 feet when the forebay is empty and Fort Randall's exclusive flood zone is filled. Neither of these extremes will prevail during a significant part of the time; together they account for less than one percent of Fort Randall's pool duration. A typical operation, consisting of Fort Randall elevation of 1352 and a mid-week Gregory County elevation of 2050, produces 698 feet of gross head. Dependable capacity was established with the forebay at minimum elevation and, Fort Randall at the base of exclusive flood control, again an event of less than one percent duration. Critical head is 711 feet. Pertinent data are summarized in Table E-7.

RELOCATIONS, MODIFICATIONS AND RIGHTS-OF-WAY - GREGORY COUNTY

88. Construction of the Gregory County pumped-storage project will require acquisition of 1,650 acres now in private ownership and the removal of seven sets of farm buildings. Road and power tunnel

Figure E-13 PUMPED STORAGE SCHEMATIC VIEW - GREGORY COUNTY



right-of-way total 165 acres, the power house and tailrace, although largely situated on project lands, require an additional 70 acres and the remaining 1,415 acres make up the forebay area.

TABLE E-7 PERTINENT DATA GREGORY COUNTY SITE (River Mile 918)

Item	Description
Total Lands Required	1,650 A
Forebay Water Surface	1,155 A
Gross Storage	47,100 AF
Active Storage	46,800 AF
Levee Length	30,100'
Levee Height, Avg.	49'
Maximum Forebay Elevation	2,081 msl
Minimum Forebay Elevation	2,020 msl
Tunnel Size	1 @ 30'
Manifold	3 @ 17'
Turbine Capacity	24,700 cfs
Pump Capacity	16,500 cfs
Draft Tube Velocity	
Generating	8.3 fps
Pumping	5.5 fps
Generators	3 @ 393.3 mw
Installed Capacity	1,180 mw
Dependable Capacity	1,080 mw
Generation Period	9 hrs/day 5 days/wk 1,000 hrs/yr
Pumping Period	8.3 hrs/day wk-days 26 hrs on week-end 1,500 hrs per year

89. Surface soil deposits at the forebay site consist of yellowish brown, loessial loam (silt and fine sand). Shallow eolian depressions are common features in the area. Neither the thickness of the loess nor top of rock elevation have been determined by subsurface exploration. No rock outcrops or glacial erratics were observed at the site, which is relatively flat with elevations ranging from about 2030 to 2070 feet msl. Rock outcrops (Ogallala formation) were observed in a re-entrant, about a mile south of the site, as discontinuous ledges from about elevation 1980 to 2000 feet msl. It is not known whether the Ogallala remnants are present under the site. Borings will be necessary to determine the loess thickness, the geologic origin and distribution or overburden materials below the loess, and the engineering properties of overburden materials. Unconsolidated deposits in addition to the loess could consist of glacially derived materials, post-Ogallala deposits from a western source, or residuum. Until further exploration is completed, the soils underlying the forebay site are considered moderately permeable to highly permeable.

90. The bluffs forming the side slopes of the Missouri River Trench are highly dissected by steep ravines extending up to several miles into the plateau. The resulting fringed topography between the plateau and trench is frequently referred to as "the breaks." Soil deposits in the Missouri River Breaks and Trench were not examined but are considered to be recent colluvial and alluvial stream and lake deposits. Some glacial outwash sediments may be present in the trench; however, they have not been differentiated in this area.

91. The following generalized stratigraphic column of Pre-Pleistocene rock units was developed, based on field reconnaissance of the Gregory County site and pertinent geologic maps:

- Remnants of what is believed to be the Ogallala formation were observed about a mile south of the forebay site. The sandstone and quartzite of this formation form erosion-resistant cap rocks over the Iona and Bijou Hills just north of Gregory County, as well as some of the higher elevations southwest of the Missouri River in Gregory County. As observed near the project site, the rock is an olive colored, hard, dense, fine-grained, siliceous sandstone with siliceous cement. Its presence and extent under the forebay site are unknown. It is believed to exist between approximate elevations of 1980 feet msl and 2000 feet msl.

● Pierre shale forms the "breaks" from elevation 1980 feet msl to lake level or about 1340 feet msl. It is generally a dark gray, easily erodible, clay shale with many layers of bentonite. The formation generally breaks down rapidly upon exposure due to its sensitivity to atmospheric conditions and tendency to swell and become plastic when wet. Subsequent drying causes shrinkage cracks, slaking and deterioration. It is highly susceptible to both aqueous and eolian erosion on slopes bordering Missouri River trench. Aerial photographs of the project site show a pronounced N 50^0 W anomalous eolian orientation of minor drainage features in the shale. Various types of landslides, creep, and mass wasting are also typical of the Pierre formation, due to its inherent weakness and the physical and chemical characteristics of the bentonite clay in the formation. The unweathered shale is firm and compact where it is not exposed or subjected to increased moisture content. The main tunnel would be constructed through the full section of the shale.

● The top of Niobrara chalk is estimated to be at elevation 1340 feet msl. The exposures observed generally consist of massive, competent, gray and white chalk. High angle jointing exists in the formation, but joints are relatively tight except where weathered near exposed surfaces. Wave action and lake fluctuations cause solutioning along joints near the lake level. Weathering of exposed chalk slopes tends to be moderately slow. The chalk is considered an excellent foundation for large structures - yet it is soft enough for machine tunneling. Landslides and mass wasting, typical in the Pierre shale along the Missouri River trench, should not affect the

Niobrara chalk at the project site. The bottom of the chalk is estimated at 1195 feet msl based on the thickness of 145 feet near the Fort Randall Dam.

- Carlisle shale underlies the Niobrara chalk. The thickness of this material is unknown in the area and it is assumed that the draft tube excavation may extend to near the top of the formation.

92. Soils of the forebay site are considered permeable. An impervious lining for the reservoir is considered necessary. Sources of lining and embankment materials and subsurface conditions at the forebay site will be determined by foundation explorations. Based on present knowledge, the forebay reservoir site is suitable for project requirements.

93. A sloping tunnel through the Pierre shale from the Powerhouse to the forebay reservoir could encounter some stability problems based on the nature of the material. Design studies may need to consider an alternative of a horizontal tunnel in the Niobrara chalk and a vertical shaft through the Pierre shale. Machine tunneling would be less difficult in the chalk compared to the shale and unstable slopes which would result in the shale with construction of the tunnel would cease to be a factor. The Powerhouse foundation would be in the Niobrara chalk. Additional subsurface excavation of shale at the toe of the bluffs along the Missouri River trench could cause slope instability above the site.

<u>MITIGATION - GREGORY COUNTY</u>

94. No mitigative measures are recommended for the Gregory County project except possibly for cultural resources. Specific needs in that field will be determined during post authorization planning. It is currently anticipated that data recovery through excavation will be adequate mitigation, and that these needs will be relatively minor in terms of both cost and scope.

Construction

95. Material for reregulation dam embankments will come from the reregulation reservoirs. Material for the Gregory County forebay embankment will be excavated from the tailrace and the forebay areas. Estimated design and construction time at Fort Peck and Garrison is 10 years, with construction taking place in the last three. Gregory County will need 13 years with five years of that for construction.

96. Post authorization studies will include early evaluation of foundation conditions at Fort Peck and at Gregory County and determination of the transmissivity of soils below Garrison, where environmental concern has been voiced over possible increases in the elevation of the water table. Model studies of Gregory County will be made to define effects on lake bottom sediment deposits and observations conducted to substantiate the present conclusion that pump back operations will have little impact on the lake fishing. With these exceptions, few construction problems are expected. Relocations are minimal; most of the necessary lands are already in Federal ownership; conventional construction practices are anticipated. Design of a gating system for the reregulation structures, which will provide automatic and reliable performance even under sub-zero conditions, promises to be a challenging but attainable task.

Operation and Maintenance

97. Operation and maintenance of the additional units will be incorporated into the on-going operation of the existing system. Daily and longer operating targets are set cooperatively by the Corps and the USBR, taking account of the water supply and the demand for electric power. Maintenance receives similar consideration in the scheduling of unit outages. Project operation during any particular day is based upon a targeted quantity of release and generation with hourly patterning as the power dispatcher sees fit.

OPERATION - FORT PECK

98. Addition of a reregulation structure below Fort Peck will contribute to flexibility of operation - enabling the project to shut down completely during periods of low demand without detriment to river conditions downstream. Figure E-14 shows typical operation of the enlarged plant with a subnormal, abundant and intermediate water supply, indicating the range in which five, six and seven-day operation may be expected. Table E-8 summarizes the discharge reregulation that is possible with 20,000 acre-feet of storage, based on maintaining a uniform downstream flow during the week, followed by a reduced but uniform flow during the week-end, thereby creating a week-end "sag" in the discharge hydrograph.

Table E-8 FLOWS BELOW FORT PECK AS REGULATED BY 20,000 AF

Weekly Average Discharge (cfs)	Days of Peaking Per Week	Hours of Peaking Per Day	Hours of Week-end Shutdown	Reregulation Discharge		Change in River Stage (feet)
				During Week	During Week-end	
5,000	7	3.7	20.3	5,000	5,000	0
5,000	6	4.3	43.7	5,000	5,000	0
5,000	5	5.2	66.8	5,900	3,600	0.8
8,500	7	6.3	17.8	8,500	8,500	0
8,500	6	7.3	40.7	9,400	5,900	1.1
8,500	5	8.8	63.2	11,450	3,800	2.4
15,000	7	11.0	13.0	15,000	15,000	0
15,000	6	12.9	35.1	17,160	6,840	2.9
15,000	5	15.5	56.5	20,450	4,250	4.6

Not required for normal power scheduling

99. During a typical week, with average discharge at 8,500 cfs and six days of power generation the following cycle will take place. On Monday through Saturday the powerplant will peak at maximum capacity of 32,600 cfs for seven to eight hours a day, dropping to zero release for the remaining hours. Starting Saturday evening there will be a no-discharge and no-generation for about 40 hours

Figure E-14 FORT PECK POWER PEAKING RELEASES

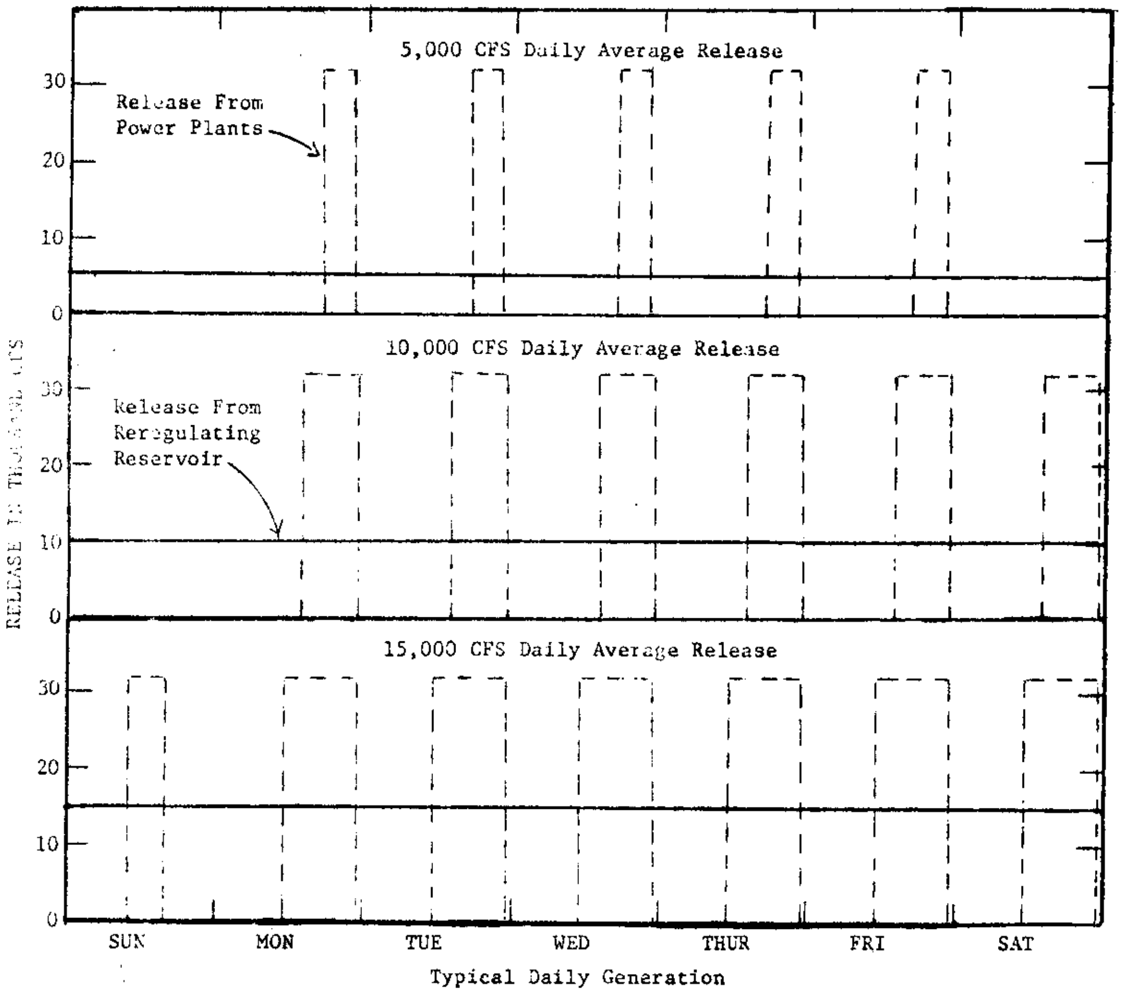
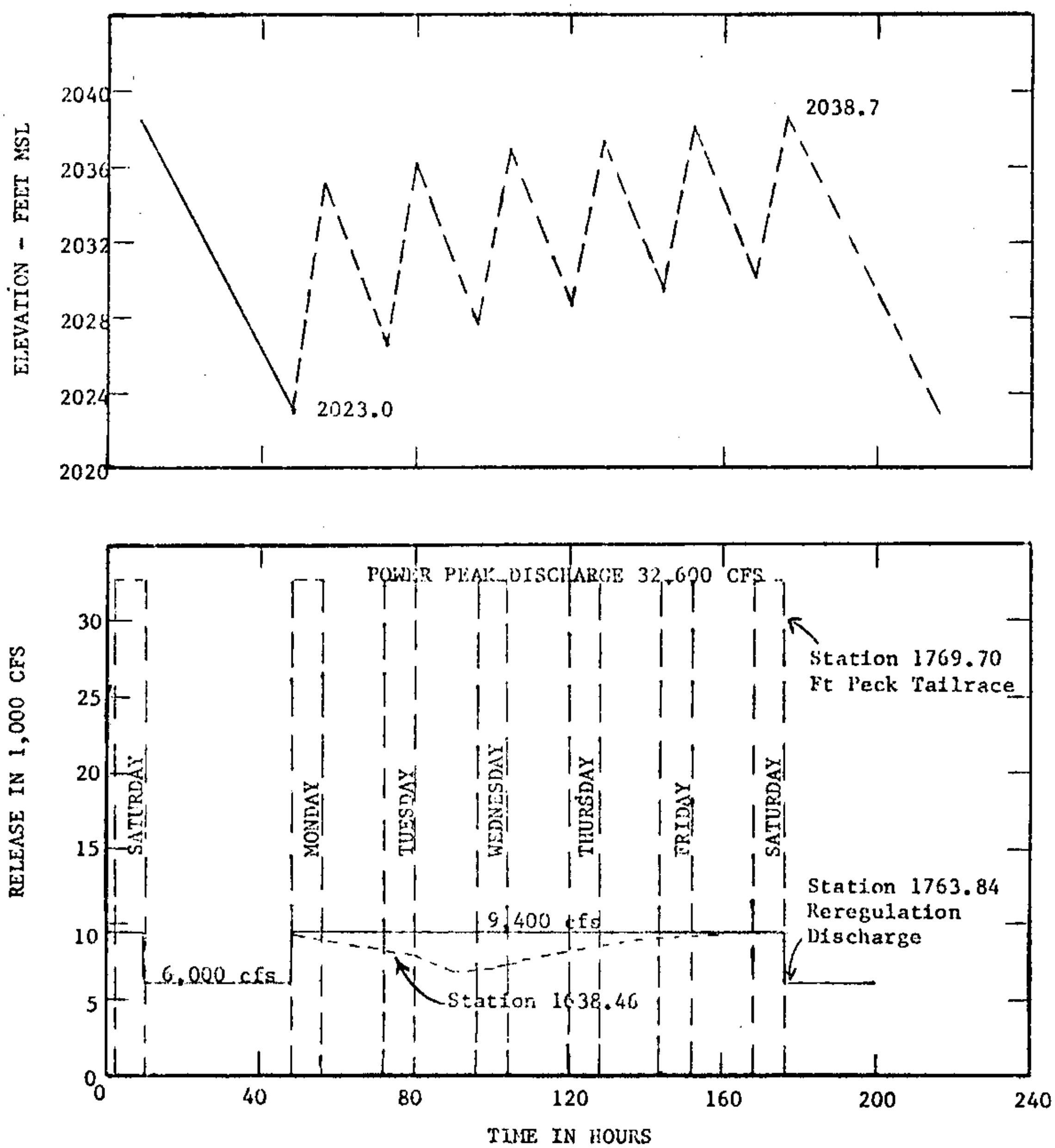


Figure E-15 FORT PECK REREGULATION WITH AVERAGE WATER SUPPLY



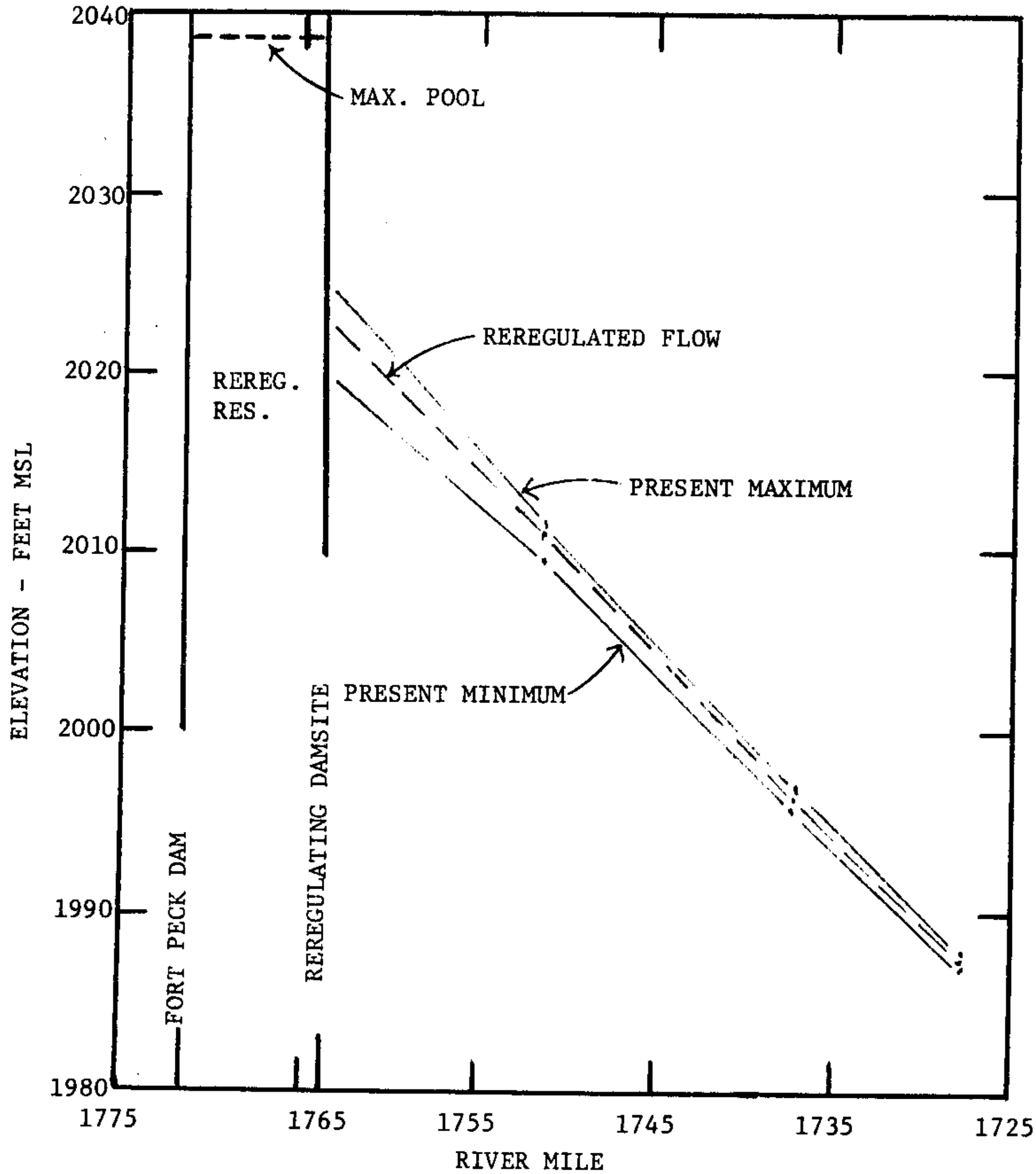
to complete the weekly cycle. On Monday morning the reregulation pool will have a water surface elevation of about 2024 just below the Fort Peck tailrace, declining to about elevation 2020 at the reregulation dam. During the week the pool will experience a daily sequence of moderate rise followed by slight drop culminating on Saturday with a flat pool elevation of about 2,039. The weekly hydrograph of pool elevation, together with releases from the power plant and the reregulation reservoir are presented on Figure E-15. At maximum elevation 2039 the reregulation pool will average 2,500 feet in width and 25 feet in depth. When the 20,000 acre-feet of reregulation storage have been emptied, the remaining water surface will average 800 feet wide and eight feet deep. At pool elevation 2039 lowlands adjacent to the present river channel and the channel islands will be inundated, except for Scout and Duck islands.

100. Releases through the reregulation dam will be uniform at about 9,400 cfs from Monday noon until Saturday evening at which time the release will be reduced to a uniform flow of 6,000 cfs for the remaining 41 hours, thereby completing the weekly cycle. The week-end "sag" from 9,400 cfs to 6,000 cfs will lower the river stage about one foot just below the reregulation dam. A second example of flow reregulation illustrating the effect downstream is shown on Figure E-16.

OPERATION - GARRISON

101. Garrison daily release rates depend upon the water supply available, the season of the year, and the power demand. Figure E-17 shows typical hourly loadings for three levels of average release, 15,000 cfs, 22,000 cfs and 30,000 cfs, representative of a summer weekend, a weekday after ice cover has formed, and a day of high summer demand. Usable storage, can be developed only upstream of the Knife River and below a pool level of 1862 at the reregulation dam; thus, it is limited to approximately 20,000 acre-feet. This will result in less than complete re-regulation (that is, in some

Figure E-16 DOWNSTREAM WATER SURFACE PROFILES - FORT PECK



remaining fluctuation) throughout a considerable range of flows. At 13,000 cfs daily average flow, complete reregulation will be obtained; discharge from the reregulation structure will be 13,000 cfs during every hour of the day even though the inflow pattern consists of 70,300 cfs (peak generation) for 4.4 hours and zero for 19.6 hours. This complete reregulation can be obtained for any average daily release below 13,000 cfs and similarly for any average daily release of 57,000 cfs or more. Between 13,000 and 57,000 cfs, the range of fluctuations is indicated by Table E-9, with a maximum of about 5 ft.

Table E-9 OUTFLOW FROM GARRISON REREGULATION POOL

Daily Average (cfs)	15,000	22,000	30,000	48,000
Max. Outflow (cfs)	20,000	37,400	47,000	57,000
Min. Outflow (cfs)	13,600	15,000	18,300	34,000
Stage Fluctuation (just below rereg dam)	1.4'	4.0'	5.0'	4.0'

102. Figure E-18a shows how the fluctuations associated with a 22,000 cfs average release (15,000 minimum to 37,400 maximum) decrease from four feet at the reregulation dam to 0.6 feet at mile 1340. In addition, it shows the downstream effect of loading the existing powerplant to 40,000 cfs for 12 hours with zero discharge for the next 12. An actual test was run on October 10, 1976, to confirm computed routings such as Figure E-18a. The results appear in Figure E-18b.

103. During the range of less than complete regulation, which corresponds to a generating range of 4.4 hours per day up to 19.6 hours per day, the reregulation pool will fill during the generating cycle to an elevation of 1682 at the downstream end. The upstream pool elevation (present Garrison tailwater) will vary depending on the slope associated with the prevailing discharge rate -- reaching a maximum of 1683 to 1685. During the non-generating period the reregulation pool level will decline, reaching elevation 1664 at the lower end and 1667 at the upper end.

Figure E-17 GARRISON POWER PEAKING RELEASES

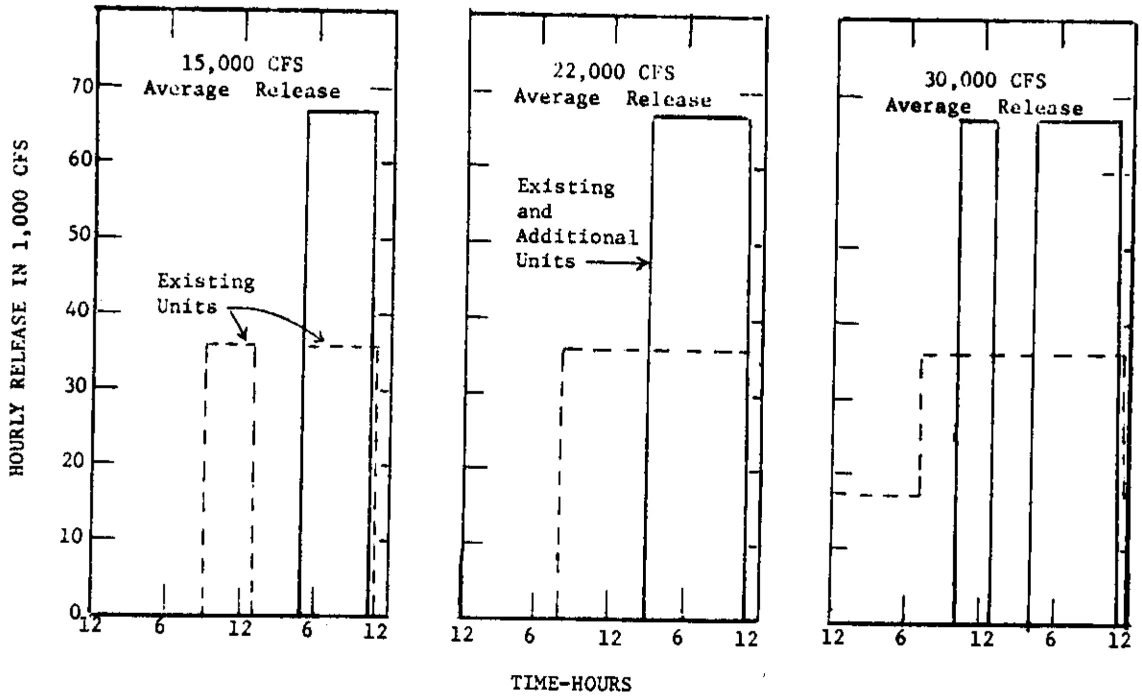


Figure E-18a DOWNSTREAM WATER SURFACE PROFILES - GARRISON

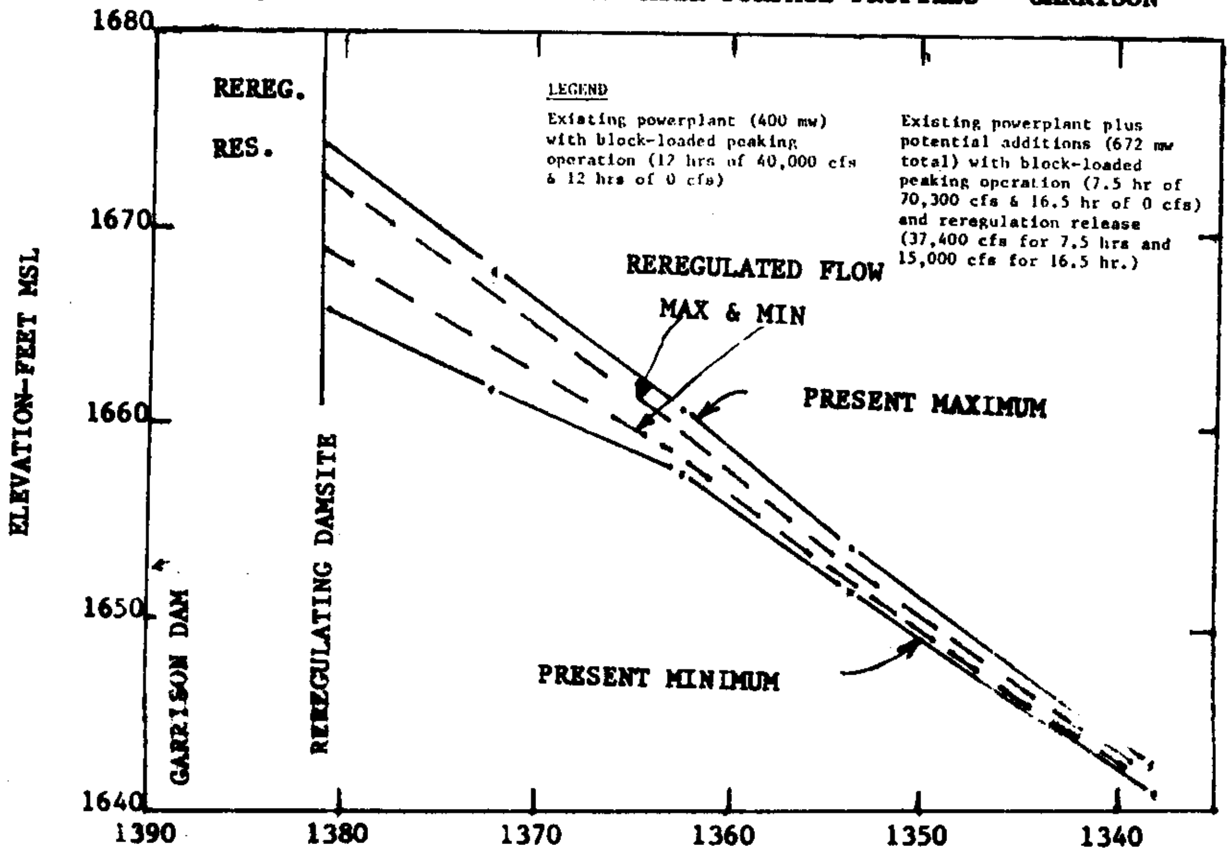
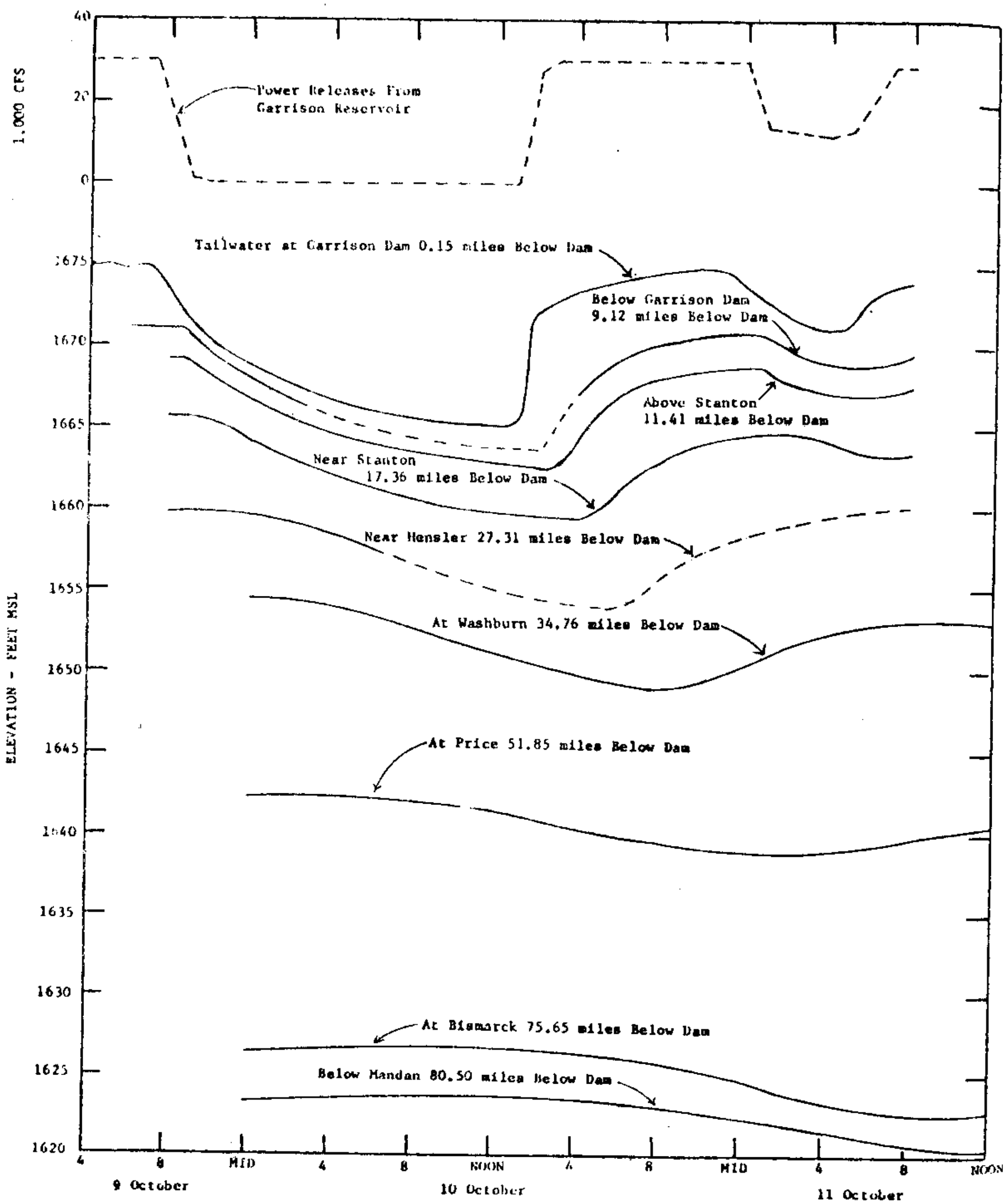


Figure E-18b EFFECTS BELOW GARRISON OF 16 HOUR ZERO RELEASE



OPERATION - GREGORY COUNTY

104. The Gregory County Pumped Storage project is designed to operate on a cycle, with on-peak generation for nine hours a day, five days a week and off-peak pumpback for about 8.3 hours a day on weekdays and 13 hours each on Saturday and Sunday. It is estimated by the Federal Power Commission that a plant of this type will be utilized about 1,000 hours yearly, resulting in an annual plant factor of 11 percent. If needed during a critical period, the project could generate continuously for 23 hours before pumpback operations had to be resumed.

105. When Fort Randall is at minimum pool (1310) the Gregory County tailwater elevation will be 1312 during generation and 1309 during pumping. Velocities within the Gregory County discharge channel (Plate E-45) during the two operational modes at that elevation will be 6.9 and 4.6 feet per second, respectively. At normal pool levels, effects of the power plant on stage and velocity will be much less. During the daily generation and pumping cycle the Fort Randall pool will rise 0.24 feet then decline 0.15 feet for a net rise of 0.09 feet. Week-end pumping will offset the week's cumulative rise by lowering the pool 0.60 feet in preparation for another cycle. The cycle in the Gregory forebay will be a daily loss of 18,400 acre-feet followed by a gain of 11,300 feet for a net loss of 7,100 feet per day; a gain of 17,750 acre-feet per day on Saturday and Sunday will refill the forebay.

Environmental Effects

106. The environmental impacts of Fort Peck, Garrison and Gregory County are a direct result of the design and operation of those projects and of certain mitigative measures such as the reregulation structure and dredge cut control works at Fort Peck, in the absence of which different effects would have ensued. This subsection perforce follows discussion of those elements; after the causes have been documented environmental effects can be assessed.

ENVIRONMENTAL EFFECTS - FORT PECK

107. As mentioned previously, a team of biologists evaluated the habitat below Fort Peck Dam using guidelines presented by the Joint Federal-State Conservation Organization Committee. Each of the five terrestrial habitat types identified was given a value between 1 and 10, from poorest to best possible on the basis of the food and cover it offers to selected "key" species. Aquatic habitat received a similar numerical rating based on biological physical and chemical parameters. The results of inventorying the area of the Fort Peck reregulation reservoir are shown in Table E-10.

108. The mitigative measures proposed to prevent stage fluctuations in the reregulation pool from being transmitted to the existing 643 acres of dredge cut lakes was discussed previously under Mitigation - Fort Peck. With the lakes thus isolated, recruitment of river fishes will no longer occur nor will paddlefish be seasonally abundant. It is estimated that isolation without future management would reduce the habitat value in the dredge cuts by about 44 percent from their present value of 8.3 units per acre. With proper management practices it is reasonable to assume the reduction will be less than 44 percent.

Table E-10 HABITAT VALUES FORT PECK REREGULATION RESERVOIR

Habitat Type	Approx. Acreage	Habitat Value Units/Acre
Aquatic (upstream of rereg. dam)		
River	1350	8.3
Dredge Cuts	643	8.3
Aquatic (downstream of rereg. dam)		
River	-	8.3
Terrestrial		
Area of Inundation	200	5.9
Area of Freeboard	700	5.9

109. The eight-mile river reach with the reregulation pool also has a present value of 8.3 units per acre. Because this pool will experience fluctuations of eight to twelve feet per day as shown in Figure E-15, fish population in the pool will be greatly reduced; the reregulation structure will bar upstream migration except during periods of flood flow. The fluctuations are also expected to eliminate most of the benthos and other invertebrate production in the reservoir area. From 8.3, the habitat value will decline to perhaps one unit per acre.

110. Below the reregulation dam week-day stages will be virtually constant to the extent that they are determined by Fort Peck power plant releases. The Milk River contribution is, of course, uncontrolled. On week-ends a stage change up to 2-1/2 feet may take place immediately below the reregulation dam, depending upon water supply and operating requirements as shown in Table E-8. The acreage of tidal area which is now periodically inundated and exposed will decrease, allowing further vegetation of these and increasing their habitat value.

111. The reregulation reservoir may moderate the downstream summer temperature regimes. At present, only 17 fish species are rated as being abundant or common in the tailrace area while 27 species are rated as being abundant or common further downstream. Cold water resulting from low level releases will be warmed in the relatively shallow reregulation pool, encouraging additional species below the dam.

112. Approximately 200 acres of terrestrial habitat, including 50 acres of islands, existing within the proposed reregulation pool will be lost due to inundation, erosion or bank slope adjustment. The habitat values of the five types comprising this 200 acres are shown in Table E-11, their weighted average value is 5.9 units per acre. Terrestrial plants, insects and small mammals existing in

the inundated area will be lost. Beaver and muskrat populations will show significant decreases while large mammal and bird populations may show slight decreases due to habitat reduction. Section <u>Mitigation - Fort Peck</u>, page E-38, discusses measures recommended in mitigation of the 200-acre loss.

113. Material used to construct the reregulation dam will come from the area upstream, where habitat, which will be flooded by the reregulation pool, has a wildlife value of 5.9 (Table E-10). Mitigation for this loss is discussed in the mitigation section.

114. Although 50 acres of island area will be lost to erosion or inundation, two islands of particular note will continue to exist after construction of the reregulation reservoir. Despite some alteration in the pattern of vegetal growth induced by undetermined changes in the groundwater regime, Scout and Duck islands are expected to retain much of their present value. Presently, they are heavily used by wildlife and on them the Fish and Wildlife Service has established a nesting flock of Canada geese producing about 40 goslings a year. Mitigative measures to reduce erosive attacks on these islands are discussed in paragraph E-74.

Table E-11 TERRESTRIAL HABITAT LOST
FORT PECK REREGULATION RESERVOIR

Habitat Type	Habitat Unit Value	Percent Composition
Shrub Grassland	6.3	15.7
Woodland	7.1	34.3
Savannah	4.2	9.6
Marsh	5.6	29.8
Cropland	4.1	10.6

115. The possibility also exists that vegetal growth patterns could be changed in the 700 acres of the freeboard zone (that area from 0 to one foot above the maximum reregulation pool elevation of 2039). Foundation explorations to be conducted during the advanced design stage will make possible an accurate evaluation of the effect which the fluctuating reregulation pool will have on groundwater levels, not only in the freeboard, but on Duck and Scout islands as well. Meanwhile, as in the case of the islands, no net loss in habitat value is anticipated because of changes in vegetation.

116. Duck Creek, a stream formed by seepage from Fort Peck Dam, remains ice-free all year and is heavily used by wintering mallards. During severe weather many of these birds starve or become seriously weakened. Concentration such as this results in the potential for outbreak of waterfowl diseases such as duck viral enteritis, which can destroy entire local populations. The creation of a fluctuating ice-free reregulation pool could compound this problem.

EFFECTS ON CULTURAL RESOURCES - FORT PECK

117. Disturbance of the earth will take place during construction of the reregulation dam and appurtenant features. Most of the terrain to be affected consists of low-lying alluvial deposits which can be expected to contain few undisturbed cultural resources. High bank disturbance will occur in placement of the right abutment of the dam, and is probable in the development of public and service access facilities. Repeated inundation during operation of the reregulation structure will affect only low-lying lands adjacent to the present channel below elevation 2039, and some steep banks near the channel will incur accelerated sloughing until a new point of equilibrium is attained.

118. The general area has a rich historical heritage and physical traces of it are abundant. Preliminary reconnaissance investigations

in the low lying alluvium downstream from the dam reveal the common presence of disarticulated bison bone, some of which represents extinct species, and fossils weathered from nearby cretaceous deposits. Pleistocene species including horse and mammoth could well be present but have not been found. Because of the annual flooding of low valley lands in the historic past, these areas were unsuitable for any extended human occupation. Functionally specific sites which might logically occur in the bottomlands include kill sites and the winter camps of nomadic hunters. Most of these were either soon covered or destroyed by subsequent flooding.

119. The probability of locating undisturbed cultural resources increases greatly along older and higher terraces and valley walls. Sites representing any of the aboriginal peoples of the area from the Paleo-Indian period to the present should be anticipated, including peripheral elements of the Plains Village tradition. When higher lands potentially affected by construction are more clearly identified, these will be included in the cultural resources survey at a later phase of study. Not more than one percent of project cost would be attributable to archeological efforts.

120. No steamboat wrecks are known to exist in the affected area. Wrecks of the Red Cloud, Butte, and Tacomy lie upstream, and the Amelia Poe is several miles downstream. Historic sites in the general area include Galpin (Galpin Village), thought to have been destroyed in the construction of Fort Peck Dam, Dauphin's Fort at the mouth of the Milk River, and the Lewis and Clark camp of May 8, 1805. Of these, only the vicinity of the Lewis and Clark campsite appears to be threatened by possibly significant adverse effect.

121. Effects on cultural resources in the approximately 40-mile reach downstream from the reregulation dam are considered to be uniformly beneficial. The regulated flow would closely resemble the slow-changing historic river flow and thus be compatible with the historical environment of sites within view of the water.

122. The aesthetic effects of an extension to the west side of the existing powerhouse to house additional generators is judged to be insignificant. Architectural design of the addition will leave it aesthetically consistant with the older portion of the powerhouse. As mentioned previously, a team of biologists evaluated the habitat below Garrison Dam using guidelines presented by the Joint Federal-State Conservation Organization Committee. Each of seven terrestrial habitat types identified was given a value between 1 and 10, from poorest to best possible on the basis of the food and cover it offers to selected "key" species. Aquatic habitat received a similar numerical rating based on "key" fish species. The results of inventorying the area are shown in Table E-12.

Table E-12 EXISTING HABITAT VALUES - GARRISON REREGULATION RESERVOIR

Habitat Type	Approx. Acreage	Habitat Value Units/Acre
Aquatic (upstream of rereg. dam)		
River	2,200	4.5
Aquatic (downstream of rereg. dam)		
River	-	5.7
Terrestrial		
Area of Inundation	180	7.3
Area of Freeboard	1,659	7.3

123. The ten-mile river reach within the reregulation pool has a value of 4.5 units per acre. Because this pool will experience daily fluctuation of 12.5 to 13.5 feet, fish population in the pool will be greatly reduced. These fluctuations will cause great stress which will adversely affect individual fish and the fish population. The reregulation dam will be an effective barrier against fish

recruitment to the reregulation pool from the river downstream. Fish reaching the reregulation pool by passing through Garrison Dam will normally be small, if healthy, and will probably be only temporary residents of the reregulation pool, being carried downstream by the "flushing" action of the water movement through the reregulation pool. The fluctuations are also expected to eliminate most of the benthos and other invertebrate production in the reservoir area. From 4.5, the habitat value will decline to perhaps one unit per acre.

124. Under existing release patterns daily stage fluctuations are 8.5 feet at the reregulation structure, five feet ten miles downstream, and three feet twenty miles downstream. The reregulation structure will reduce the fluctuation to 4-5 feet at the reregulation structure, 2.5 feet ten miles downstream, and one foot twenty miles downstream. These reductions represent an average stage fluctuation decrease of approximately 50 percent. The acreage of tidal area which is now alternately inundated and exposed will decrease, increasing the opportunity for establishment of semi-aquatic rooted vegetation of these acres, thereby increasing desirable riverside habitat.

125. It is likely that short-term water retention in the reregulation pool will moderate downstream river water temperature regimes which could result in improved relative abundance of fish for a short distance downstream from the reregulation structure. However, this effect remains to be quantified and qualified. The Garrison tailrace supports a rather diverse variety of fish species as evidenced by a 10-year creel census of the Garrison tailwaters conducted by North Dakota and several "grab sample" gill nettings made by the FWS in early winter of 1975. In addition to the minnow family, excluding the European carp, the creel census, supported in large measure by the findings of the FWS nettings, recorded 30 fish species. With respect to sport fishes, sauger, walleye, northern pike, white bass

and channel catfish are most important. Goldeye appears to be the most significant forage fish other than the cumulative importance of the minnows. Little commercial fishing occurs in the river today reflecting the general lack of significant numbers of non-sport, commercial fishes. A conclusion made of the creel census data was that Lake Oahe has been the most important influence on the fishery in the river below Garrison. For the most part, however, forage fish species are indigenous to the river and are not greatly influenced by Lake Oahe. The significant increase in the numbers of northern pike taken in the Garrison tailwaters in 1964 and 1965 corresponds with the very successful northern pike reproduction in Lake Oahe; several northern pike tagged in Lake Oahe were recovered in the Garrison tailwaters. These data further support the conclusion that Lake Oahe signficantly influences the fish population in the open river below Garrison. Northern pike also utilize tributaries of the Missouri River, such as the Knife River, for spawning; thus, also influencing the fishery of the river. Walleye numbers in the river appear tied to Lake Oahe. Creel data show a significant increase in walleye beginning in 1968 - the year that numerous gravel deposits along the Missouri River were inundated by Lake Oahe. Such sites, it is believed, served as spawning sites for walleye. Again, this supports the conclusion that Lake Oahe is a significant influence on the river fishery. Sauger numbers, on the other hand, showed little overall change during the 10-year creel census period (covering years before Lake Oahe became operational in 1962) although there were significant yearly fluctuations during the 10-year period. It could be concluded that this river species is little influenced by Lake Oahe, except possibly in a negative way. The tailrace area and the "pike hole" area located about 2-1/2 miles below the dam are the only specific areas of intensive fishing use that have been identified in the river between Garrison and Lake Oahe. The fluctuating reregulation pool will doubtless eliminate these areas. It is expected that a fishery similar to that existing in the present tailrace area will develop below the reregulation structure; however, the "pike hole" area probably will not be duplicated downstream of the reregulation dam.

126. Approximately 180 acres of terrestrial habitat will be inundated within the proposed reregulation pool. Another 20 acres will be lost due to bank slope adjustment within the reregulation pool area. The habitat values of the types comprising this 200 acres are shown in Table E-13.

Table E-13 TERRESTRIAL HABITAT LOST
GARRISON REREGULATION RESERVOIR

Habitat Type	Habitat Unit Value	Percent Composition
Bottomland Hardwood	7.2	6
Bottomland Savannah	7.3	22
Sand Bar	6.8	68
Cropland	8.6	-
Floodplain Wetlands (Marsh)	7.7	1
Open Herbaceous	7.3	3
Island	7.2	-

The weighted average value of the land lost consists of 68 percent non-vegetated sand bar, 22 percent bottomland savannah, six percent bottomland hardwood and three percent open herbaceous is 7.3 units per acre. The sand bar area is not being recognized in computing habitat mitigation needs since this area will be replaced downstream as a result of decreased stage fluctuations. Terrestrial plants, insects and small mammals existing in the inundated area will be lost. Beaver and muskrat populations will show significant decreases while large mammal and bird populations may show slight decreases due to habitat reduction. Measures recommended for mitigation of the 200-acre loss are discussed under Mitigation - Garrison, page E-47.

127. Material used to construct the reregulation dam will come from the area upstream, where habitat, which will be flooded by the reregulation pool, has a wildlife value of 7.3 (Table E-12). Mitigation

for this loss is discussed under Mitigation - Garrison, page E-47.

128. Considerable concern has been expressed over the possible impact of increased stage fluctuation on existing ground water levels particularly in the game management area below the dam. The general class of valley soil adjoining the river varies from sand to clay averaging sandy clay loam. These soil types, except clay, are quite permeable, offering relatively little resistance to movement of groundwater in response to river fluctuation. Thus, the possibility exists that vegetal growth patterns could be changed in the 1659 acres of freeboard zone (that area from 0 to 3 feet above the maximum reregulation pool elevation of 1682). Foundation explorations to be conducted during the advanced design stage will make possible an accurate evaluation of the effect which the fluctuating reregulation pool will have on groundwater levels. Meanwhile, no net loss of habitat value is anticipated because of changes in habitat types.

EFFECTS ON CULTURAL RESOURCES - GARRISON

129. Direct impact on cultural resources in the low valley lands inundated is expected to be minor. Frequent flooding of these areas in historic and prehistoric times made them generally unsuitable for extended occupation. Cultural resources reconnaissance of the area that will be potentially affected by the selected plan will be performed during detailed design studies. This will include reconnaissance of the reregulation reach and dam, and of areas which may be visually affected to a significant degree. Specific efforts will be directed to the discovery of relevant data pertaining to the sites of Fort Mandan and Fort Lisa. Specific impacts on known or discovered cultural resources will be identified. An assessment of reasonably identifiable trade-offs of cultural resources values will be completed prior to recommending the selected plan for final authorization.

130. The reregulation dam is located just upstream of the Knife

River Indian Villages National Historic Site. Design of this structure and associated features will be directed toward minimized visual impact on the historic site.

ENVIRONMENTAL EFFECTS - GREGORY COUNTY

131. Three adverse effects regarded as potentially significant have come under consideration during the evaluation of Gregory County; one, associated with construction, is unavoidable; the others, associated with the operation, are conjectural at best and may lose their threat following additional study.

- A productive natural embayment will be pre-empted and its flora and fauna in large measure destroyed, to provide a site for the power plant and tailrace channel.
- Operation of the power plant in the pumping mode may draw fish into the pump turbines or otherwise inflict death or injury.
- Operation of the power plant in the generating mode may disturb sediment deposited by the White River, increasing turbidity and degrading water quality to the detriment of the aquatic community.

132. The embayment within which the discharge channel will be situated occupies about 20 acres; all of the existing habitat will be destroyed. An embayment is here considered to be the flooded segments of a drainage system which are protected by headlands from disturbance by littoral waves or currents and as a result are highly productive. At a typical summer pool elevation, Lake Francis Case has over 500 miles of shoreline with about 40 acres of embayment per mile for an estimated total of 20,000 acres. The Gregory County site will thus destroy one-thousandth part of the embayment resource at Francis Case. This is a significant impact upon that particular embayment, but not upon the entire resource of the project.

133. During the pumping mode, maximum discharge channel velocities of 4.6 feet per second were given in paragraph E-105. One possible

effect is the diversion of stream-seeking fishes which would follow the currents created by the pumpback unit to the powerhouse rather than tributary inflows. At present, data are not available specific to Lake Francis Case fish populations to judge the severity of this effect. Some mortality can be expected due to passage of fishes through the powerhouse turbines. The FWS has said this mortality will be unacceptable unless screens are installed. However, research on the Muddy Run pumped storage project indicates that no significant population reduction has occurred as a result of this type of mortality. This research also indicates that greater mortality may occur with the installation of screens due to "gilling" or trapping of fishes against the screen. Studies during advanced design will address the two decisive questions:

- What fish population may be expected in the vicinity of the intake channel, which will lie 60 feet or more below the surface during three-fourths of the time it is operating?
- Does the fish population, once determined, merit protection, or is the expected mortality a reasonable price to pay for more than one million kilowatts of peaking capacity?

134. The likelihood that Gregory County will cause an increase in turbidity (a reduction in transparency caused by sediment in suspension) depends upon interaction between the turbine discharge current and the White River delta. The White River is a right-bank tributary which joins the Missouri about 75 river miles above Fort Randall Dam and about 37 miles above the recommended Gregory County site. It discharges an annual average of 15,000 acre-feet of sediment into Lake Francis Case - about 90 percent of the lake's total sediment inflow. The sediment consists largely of montmorillonite, a type of colloidal clay with a saturated density about that of water. After perhaps a year of consolidation on the lake bottom, however, it develops very considerable stability and resistance to waterborne transport.

135. The White River also plays an important role in the lake's

water quality. Based on readings just below the mouth, its sediment contains iron and manganese in concentrations 10 to 100 times greater than those reported as dissolved solids. This suggests their presence in the sediment to be highly insoluble, otherwise the prolonged suspension period would result in leaching and a closer balance between the sediment and water. It appears that the effect of the White River on water quality in the lake has reached equilibrium and that minor turbulance downstream will have little effect on water quality.

136. Since initial fill of Lake Francis Case in 1952, the White River delta has progressed downstream some 28 miles, putting the toe about seven miles upstream of Gregory County. The White River deposits will, in time, move as far as the Gregory County site; it is estimated this will occur within twenty years. What happens then will depend on the other element in the equation: the turbine discharge current. The maximum average velocity of 6.9 feet per second in the discharge channel applies when the Fort Randall pool is at elevation 1310. Where the embayment debouches into the main body of Lake Francis Case, 3,000 feet away from the landward end of the discharge channel, average velocities will exceed 2.6 feet per second less than ten percent of the time (only when the pool elevation is below elevation 1330).

137. Density currents could be created by the discharge of warm water from the Gregory County forebay. Based on past experience these very low velocity currents pose little threat to water quality.

138. Other effects of construction and operation have not received as much concern over their potential.

- It is expected that fall migrating waterfowl will use the forebay as a resting site.
- The operating cycle will cause some circulation of nutrients. It is probable that emergent, rooted aquatic vegetation will develop on the "wind-shadow" periphery of the upper pool which, in turn, will add invertebrate and algal biomass to Lake Francis Case.

● The project is expected to have little effect on lake temperature or dissolved oxygen. Current data indicate that neither a distinct thermocline nor appreciable oxygen deficiency occur in the lake. The maximum temperature differential existing near the project area generally does not exceed $10^{0}F$ from the surface to the lake bottom, and oxygen levels are usually 90 to 100 percent of saturation.

● Construction activities will cause an insignificant adverse effect on air and will add noise to the area. Temporary increases in the turbidity of the embayment area may extend some distance into the lake during construction of the discharge channel.

139. Approximately 1,415 acres of terrestrial habitat, of which nearly 100 percent is cropland, will be destroyed by construction and subsequent impoundment of the forebay. This site lies within the range of the blacktail prairie dog in South Dakota. The black-footed ferret, a Federally recognized endangered species, utilizes prairie dog towns as a critical part of its total habitat needs. Black-footed ferrets have been recorded approximately 20 miles northwest of the Gregory County site. No prairie dog towns are known to exist on the site in its immediate proximity. Therefore, there should be no effect on the black-footed ferret (endangered species) or a critical part of their habitat (prairie dog town). There will be an insignificant effect on other wildlife populations in the area; although the smallest mammals, reptiles and insects would be destroyed by project construction.

EFFECT ON CULTURAL RESOURCES - GREGORY COUNTY

140. The proposed action is characterized by large scale earth movement and alteration of terrain. Any cultural resources in the construction area will be destroyed. The historical setting of any sites within view will be disrupted; constituting an adverse effect.

141. Prehistoric sites in the general area are fairly common, though none have yet been recorded in the area of direct impact.

Reconnaissance studies have revealed one prehistoric site of undetermined character and significance which might be destroyed. This site is at least partially deflated. No homesteads or other historic sites were found. On the basis of reconnaissance, at least two other prehistoric sites will probably be found through post-authorization survey. Destruction or damage requiring mitigation is projected for these sites also.

142. Marketing of the additional power will require some additions to the existing transmission grid. Federal transmission lines in this region are constructed and maintained by the Bureau of Reclamation.

Transmission Facilities

143. The Bureau does not regard as feasible an in-depth examination of alternative transmission schemes until the source of generation has been authorized by Congress. The U. S. Fish and Wildlife Service has requested that the report show it does not believe hydro-power alternatives can be selected and environmental impacts assessed until associated impacts from transmission line construction are analyzed. When that has been done, the Bureau will prepare a complete report, complete with Environmental Impact Statement. Meanwhile, the Bureau has identified several corridors along which future transmission lines may be built.

- Fort Randall to Sioux Falls, South Dakota
- Fort Randall to Sioux City, Iowa
- Fort Thompson, South Dakota to Sioux Falls, South Dakota
- Fort Peck to Williston, North Dakota to Tioga, North Dakota
- Sioux Falls to Lakefield Junction, Minnesota
- Garrison to Bismarck, North Dakota
- Garrison to Jamestown, North Dakota
- Augary County Site to Fort Randall

144. Installation of new transmission lines would disturb the landscape during construction, require 22 acres of agricultural land for each 100 miles of line for tower structures; increase visual impact at highways and recreation areas; reduce vegetation through clearing of right-of-way; and reduce animal populations from clearing operations and bird populations through collision with lines. Areas disturbed during construction would be revegetated consistent with present land use. An area of 10 to 15 acres would be required for terminal facilities at each end of the line. Existing uses would be expected to continue in the right-of-way area except for the area needed by the towers.

On-site Rearing Ponds

145. The selected plan calls for Federal construction together with neighboring forage base development of nine-acre on-site fish rearing ponds at seven locations on Lake Oahe and five on Lake Francis Case for northern pike propagation.

Plan Description

146. The plan consists of two separate actions. The first is the establishment of semi-aquatic vegetation on a number of reaches of denuded lakeshore areas at Lake Oahe and Lake Francis Case. At each of twelve sites identified on Table E-14 and Figures E-19 and E-20, about 200 acres will be seeded by conventional farming methods during the late fall and winter months. Sprigging of root stock from rooted semi-aquatic plants will also be performed on 100 acres during the same period. Subsequent rises in pool levels during

Figure E-19 ON-SITE REARING PONDS - LAKE OAHE

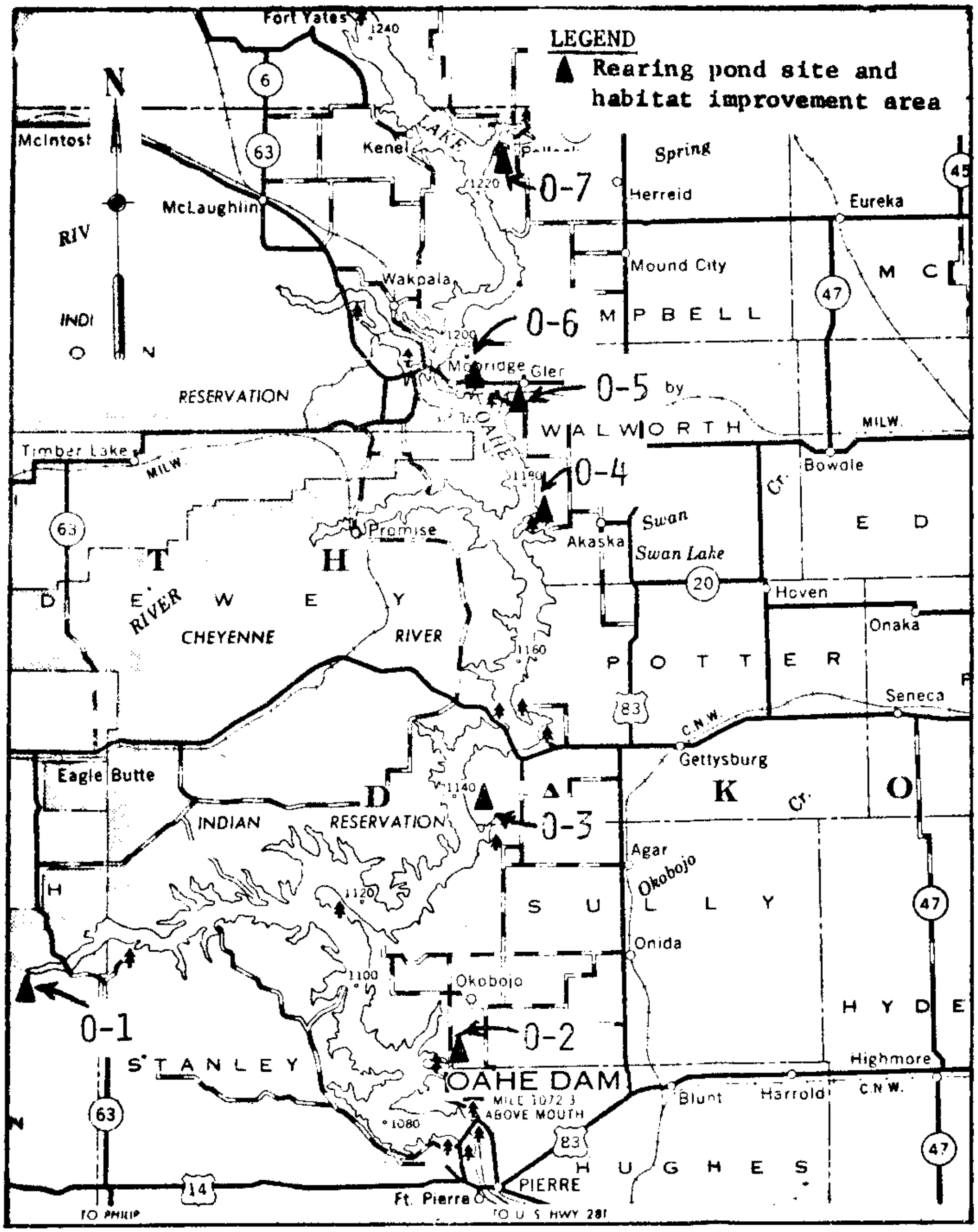
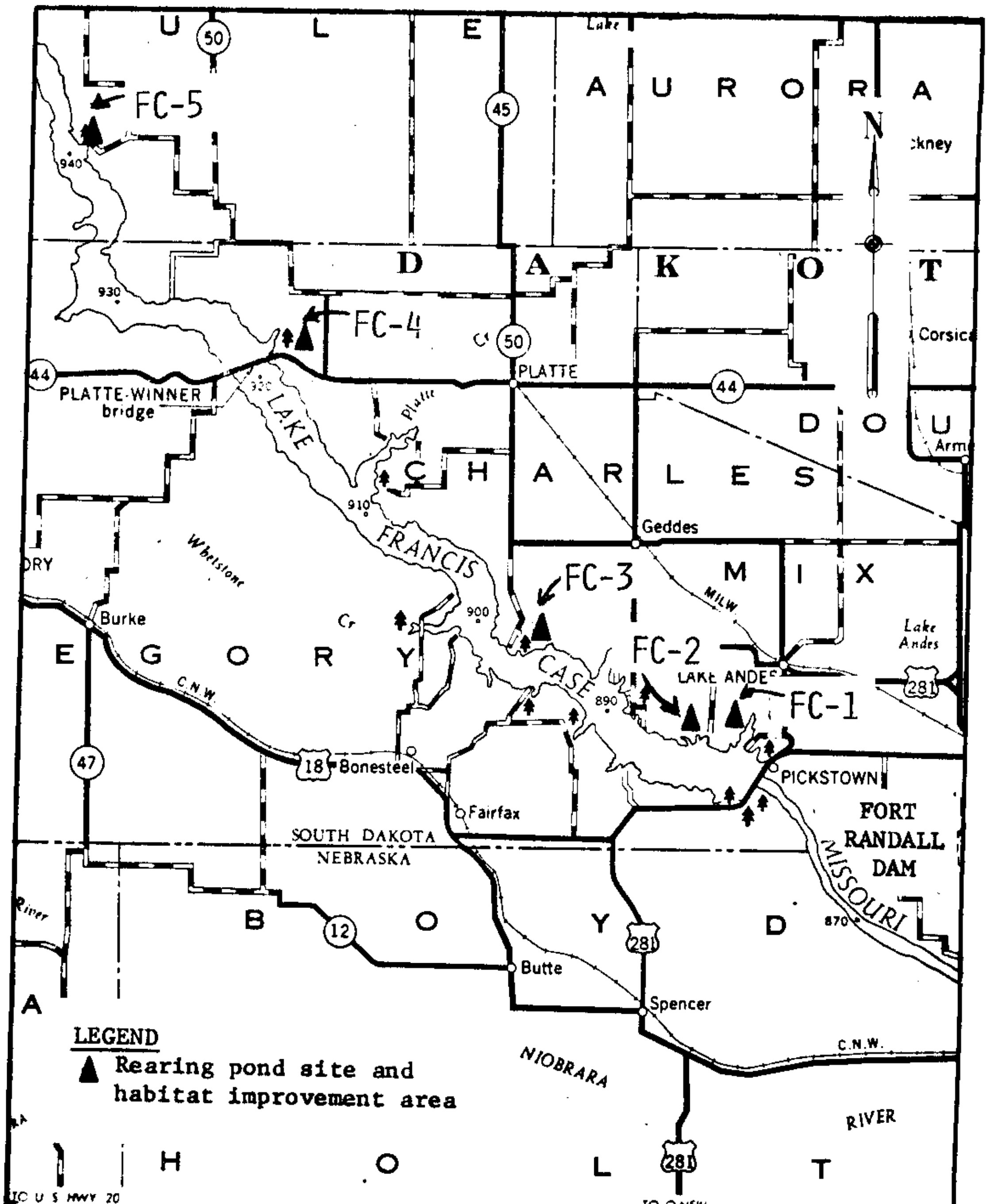


Figure E-20 ON-SITE REARING PONDS - LAKE FRANCIS CASE



the summer months will inundate plant growth in the seeded area thereby creating littoral habitat suitable for growth, reproduction and maintenance of prey fish species. This forage base improvement will eliminate the need for stocking prey species and will provide the northern pike with a perpetual forage base.

Table E-14 ON-SITE FISH REARING PONDS AND FORAGE BASE DEVELOPMENT

Lake	Geographical Location	Map Designation
Oahe	Cheyenne River Arm	O-1
	Cow Creek Area	O-2
	Whitlock Bay Area	O-3
	Swan Creek Area	O-4
	Blue Blanket Area	O-5
	Indian Creek Area	O-6
	Pollock Area	O-7
Francis Case	North Bay Area	FC-1
	St. Phillips Bay	FC-2
	North Wheeler Area	FC-3
	Snake Creek Area	FC-4
	Elm Creek Area	FC-5

147. The second part of the plan consists of constructing rearing ponds at the 12 selected sites. Each would be located near the improved habitat area and have an access road and electric power source. Five sites would have space for temporary parking of a hatchery trailer and mobile home-office and an underground waste storage vault. Each pond would be 706 feet in diameter, surrounded by a levee with a height ranging from four feet to 10 feet. A slope of about 100 feet horizontal to one foot vertical on the bottom of the pond will maintain water depths ranging from about one foot on the landward side to about eight feet on the lakeside. Portable pumps will fill the ponds and maintain water levels, and selected mobile peripheral equipment such as hatchery trailers will be necessary to monitor the ponds. Pond drainage will be accomplished through a sluice gate located in the levee and a corrugated metal pipe will discharge water and fingerlings into the lakes.

Plan Accomplishments

148. The implementation and operation of the plan would:

- Improve existing forage base consisting of increased numbers of prey fish species, insects, and other invertebrates
- Reduce shoreline erosion and stabilize banks along an estimated 200 miles of denuded shoreline
- Improve the lakes' northern pike populations
- Increase fishing opportunities and visitation to the lakes by about 180,000 fishermen days annually.

149. The construction and operation of on-site rearing ponds for the production of northern pike will result in significant increases in the pike fishery caused by the production and release of approximately five million fingerling northern pike annually. This, in turn, will increase visitation at these lakes, as well as their geographic area of influence, resulting in their re-establishment as regionally important northern pike fishing lakes, a position each once held during initial fill.

Effect on the Environment

150. The rearing ponds will have no major adverse effects on the environment and will result in an improvement over existing environmental conditions. Approximately 1,400 acres of denuded shoreline area at Oahe and 1,000 acres at Francis Case will be vegetated, marked by improving existing habitat both when inundated and when exposed.

151. One hundred forty acres of terrestrial habitat will be destroyed by the construction and operation of 12 on-site rearing ponds. Much of this area presently supports little vegetation. Seeding and re-establishment of vegetation in the rearing pond bed each year may result in improved terrestrial wildlife habitat during non-operational periods.

152. A corrugated metal pipe will be placed between each rearing

pond and the lake, a distance which varies from site to site. This activity will have little environmental effect, since these areas are presently denuded and will be seeded after the pipe is installed.

153. Gravel access roads will be constructed from existing public roads to each rearing pond site; required extensions of existing gravel roads will vary from 50 feet to 1,800 feet. The bulk of this construction will occur in areas where project trails exist and the effect on existing vegetation will be minimal.

Other Effects

154. The construction of on-site rearing ponds will result in the employment of about 60 construction personnel during peak construction actions.

155. Recreation surveys conducted in 1965 and 1975 at Lakes Oahe and Francis Case show a major decline in fishing by people coming from beyond 100 miles. This loss is correlated with the deterioration of northern pike fishing success. About 172,000 northern pike-oriented fishermen who traveled to the lake from beyond 100 miles in 1965 are not doing so today. About half of this number came from outside of the State of South Dakota; an additional 9,000 fishermen from within 100 miles would return to the lake to fish for northern pike. The in-state and out of state total, rounded to 180,000, is regarded as a very conservative estimate.

156. Increased regional sales specifically associated with this gain in fishermen will be approximately $1.3 million annually, resulting in a net regional benefit of $930,000. The capacity for about 300 additional seasonal and part-time jobs will be added. Total additional sales and gasoline tax for the region will be about $86,000, approximately one-half of which will be new nonresident revenues.

157. Some increase in out of state tourism - over and above fishermen themselves - is anticipated in response to the establishment of an assured trophy-fish population. The impact will be social as well as economic, establishing a stable base for added seasonal employment besides increasing total income. An indirect social and economic effect of the restored fishery, stemming from its contribution to the attractiveness of South Dakota as a place to live, should be an impetus on industrial development and population growth.

Design

158. Establishment of a northern pike forage base will involve sprigging and seeding alternately exposed and inundated lake shore areas in the vicinity of the rearing ponds. Vegetational establishment of this type has been accomplished by the Corps of Engineers in the creation of salt marshes in the Chesapeake Bay area and has been studied on Lakes Oahe and Sakakawea. The vegetational establishment will consist of an initial sprigging or transplanting 100 acres at each site of various rooted semi-aquatic plants suited to the climatic conditions of the area. Suitable root stock will be harvested from lake shores and wetlands located a short distance east of Lakes Oahe and Francis Case. In addition to the initial sprigging, approximately 200 acres along the shoreline area at each pond site will be seeded initially and aerially reseeded on an annual basis for a period of five years. During this time the vegetative stands should become selfsustaining, thus terminating the need for annual seeding.

159. To maintain a viable trophy northern pike fishery in Lakes Oahe and Francis Case, it will be necessary to stock these lakes on a yearly basis. The mortality involved with this stocking effort will vary widely from year to year and between life cycle stages depending on environmental conditions such as food

availability, cover, temperature, etc. With suitable pike habitat estimated to constitute less than one-third of these lakes, it will be necessary to stock approximately 3,000,000 fingerlings in Lake Oahe and 2,000,000 fingerlings in Lake Francis Case annually in order to maintain a minimum adult pike population greater than three fish per acre of suitable littoral habitat. These fish will not be evenly distributed but will tend to congregate in the more favorable areas for food and cover, creating fishing "hotspots." Table E-15 indicates approximate numbers and the mortality associated with each life stage that can be expected to occur.

Table E-15 POPULATION AND MORTALITY ESTIMATES - HATCHERY REARED NORTHERN PIKE

	Lake Oahe	Lake Francis Case
Number of Eggs	12,000,000	8,000,000
Mortality	10-20%	10-20%
Yolk-sac larvae	10,000,000	6,600,000
Mortality	40%	40%
Fry	6,000,000	4,000,000
Mortality	50%	50%
Fingerlings Released	3,000,000	2,000,000
Mortality	90%	90%
Adult Northern Pike	300,000	200,000
Avg Adult Pike/Acre	3	6

160. The rearing pond structure will consist of a ring levee with side slopes of 1 on 3 and a 10-foot top width. A 2-3/4 foot corrugated metal pipe will extend from the sluice gate structure to the existing lake for draining the pool. The pool will be drained over a two-day period and filling time will approximate one day with portable 65-horsepower pumps. The bottom of the pond will be graded to a 1 on 100 slope and seeded annually. The top of the levee will be surfaced with gravel as will the extension of existing roads to provide access to the site. The site will be located at or above the elevation of the top of exclusive flood control zone of the reservoirs. Locations at this elevation would be

subject to flooding from the lake less than once every 100 years.

Construction

161. After final site selection has been made in the post-authorization phase, utilizing the results of foundation exploration and efforts to minimize grading operation and lake access costs, construction will require about six months. Techniques employed will be quite similar to those used in building sewage ponds. A particular concern is to minimize chances of inundating the ponds by upland runoff or high lake levels.

162. The process of establishing a vegetative cover along the lake shore by initial seeding must be followed up by a five-year program of aerial reseeding as discussed in paragraph E-162. This effort is a part of the Federal construction cost. All other features of this project, including the annual requirement for pond seeding, will be turned over to the sponsor after completion during the first year of construction.

Operation and Maintenance

163. The South Dakota Game, Fish, and Parks Department will be responsible for annual operation and maintenance consisting of:

- Pond farming
- Egg collection and rearing to the fingerling stage
- Release of fingerlings into the lakes.
- Maintenance of ponds, equipment, and access facilities

164. Pond farming will involve annual seeding of the rearing pond interior during the summer months using plants which decay easily after inundation. This decay after the spring pond filling will result in a rapid growth of zooplankton to be utilized as a food source by the northern pike fry. Any necessary maintenance of the embankments can also be accomplished at the time of seeding. The vegetated shoreline will not require annual maintenance since it

will maintain itself and perhaps expand after the five-year initial seeding program.

165. Egg collection will begin during the March-April period when ripe females and males can be collected in Eastern South Dakota lakes or elsewhere. The precise time of collection will be determined by hatchery personnel since it varies with environmental conditions. This collection process will take one supervisor and five men approximately ten days. Once the ripe females and males are collected they will be milked or stripped and the fertilized eggs placed in egg jars in the modified hatchery trailers. The three trailers will then be moved to rearing pond locations on Lakes Oahe and Francis Case. Operation of hatchery trailers will require one supervisor and five part-time employees. This operation will involve monitoring physical and chemical water conditions, transferring yolk-sac larvae from egg jars to larvae troughs housed in the hatchery trailers, and releasing the pike fry into the rearing ponds. Rearing pond operation will involve one supervisor and an emergency crew to monitor food, water, temperature, release time, etc. and correct any deleterious conditions which may arise. At the proper time, as determined by hatchery personnel, the fingerlings will be released into the lake in the habitat improvement areas.

166. Pond maintenance and filling will begin approximately two to four weeks prior to fry release time as determined by hatchery personnel. Maintenance to access roads, levees, sluice gates, etc. will be accomplished as needed throughout the year. Pond filling operations will be accomplished using portable pumps to fill each rearing pond from the nearby lake. Make-up water for evaporation and seepage losses would also be provided periodically by the pumps.

Reach Designation Under National Wild and Senic Rivers Act

167. The selected plan proposes that the reach from Gavins Point Dam to Ponca State Park be designated as a component of the National Wild and Scenic Rivers system. Preservation of the outstanding values of the reach will be carried out through acquisition of scenic and recreational easements sufficient to satisfy the public interest, and a minor amount of fee acquisition necessary for facility development. Structural controls necessary to preserve outstanding natural values within the river's high banks are included. Those outstanding features which provide the eligibility for designation and which could be adversely affected by Section 10 and Section 404 permit actions will be preserved by inclusion of appropriate constraints in the permits. Examples are screening of pumps with plantings and limitations on exhaust noise. The bank protection plan described at the beginning of Section E will be designed and constructed so that no structure is introduced which would have significant adverse effects on the outstanding values in the reach.

168. The remaining paragraphs of Section E, except for the discussion of operation and maintenance, have been prepared by the Bureau of Outdoor Recreation, utilizing data acquired by that agency and by the Corps of Engineers in their joint evaluation of the study reach. Requirements and report format vary among agencies; a part of the discussion which follows might appear to have been appropriate for consideration under topic headings in earlier sections; other parts are repeated in Sections F and G. Some small element of repetition, however, seems a modest price to pay for this assembly of a report within a report -- document which can serve the purposes of both the Department of Interior and the Department of Army as

they move to further process its findings.

Purpose

169. This part of the umbrella study was done to evaluate alternatives for management of the 59.05-mile reach of the Missouri River from Gavins Point Dam to Ponca State Park. In developing the alternatives, the river reach was evaluated using the procedures and guidelines of the National Wild and Scenic Rivers Act; however, the study was not done specifically directed by the National Wild and Scenic Rivers Act, Public Law 90-542.

170. The act established the National Wild and Scenic Rivers System, designated eight rivers as initial components of the system, identified 27 rivers for study as potential additions to the National System, and prescribed methods and standards by which additional rivers could be added to the system from time to time. Subsequent amendments have identified 31 additional rivers for study; however, the Missouri River from Gavins Point to Ponca State Park is not specifically identified in the above legislation.

171. This section of the report contains basic data pertaining to the Gavins Point Dam to Ponca State Park river study area, study findings, conclusions, recommendations, and a discussion of alternative actions. In addition, the report includes a conceptual river plan which provides guidelines for the preservation, utilization, and management of the Missouri River from below Gavins Point Dam, South Dakota, downstream 59.05 miles to Ponca State Park, Nebraska.

172. A river, or segments of river, qualifying for inclusion in the National Wild and Scenic Rivers System shall:

> "with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment

of present and future generations. The Congress declares that the established national policy of dams and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."

Scope

173. Information as presented on this portion of the Missouri River Study is the result of field work and analysis on the part of State and Federal agencies. The study has evaluated this 59.05-mile segment for possible inclusion in the National Wild and Scenic Rivers System.

Conduct of Study

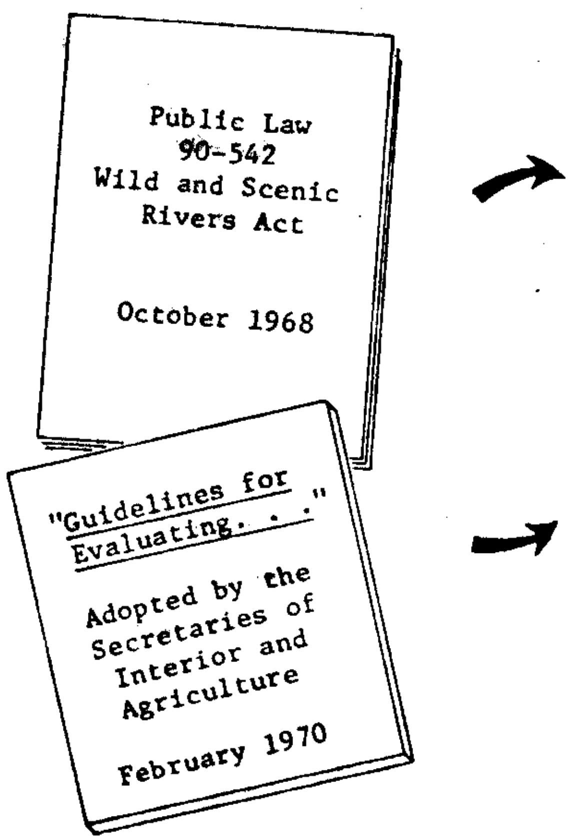
174. The study of the Missouri River from Gavins Point to Ponca State Park has been part of the overall "Missouri River Umbrella Study" and has given full consideration to the potential of that segment of the Missouri River for inclusion in the National Wild and Scenic River System. The study report and environmental impact statement of this segment of the Missouri River were designed to comply with the requirements and guidelines of the Wild and Scenic Rivers Act.

175. A study group composed of Federal, State, and local agencies was initially organized in early 1976 under the leadership of the Missouri River Division, Corps of Engineers. Federal agencies represented included the Bureau of Outdoor Recreation, Fish and Wildlife Service, and the National Park Service. State representatives included Nebraska Game and Parks Commission, South Dakota Department of Game, Fish, and Parks, and State historians. County commissioners from those counties directly related to this segment of the river were also involved. Public involvement included two Umbrella Study public meetings held in June of 1976. Comments expressed during these meetings are summarized in paragraphs C-168 and C-169.

Eligibility Determination and Classification Procedure

176. The first basic task in conducting this river study was to determine whether or not the river or segments of it met the eligibility criteria as set forth in the Wild and Scenic Rivers Act and the "Guidelines for Evaluating Wild, Scenic, and Recreational River Areas Proposed for Inclusion in the National Wild and Scenic Rivers System as Adopted by the Secretaries of the Interior and Agriculture." In other words . . .

DOES IT QUALIFY FOR THE NATIONAL SYSTEM?



ELIGIBILITY CRITERIA

FREE FLOWING CONDITION

ACCESSIBILITY

SHORELINE DEVELOPMENT

WATER QUALITY

SCENIC QUALITY

FISH AND WILDLIFE VALUES

RECREATION VALUES

GEOLOGIC FEATURES

CULTURAL AND HISTORICAL VALUES

Classification Categories

177. If a river is found to qualify for the National System, the second basic task is to determine the appropriate classification under the following categories:

- Wild river areas - Those areas or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.
- Scenic river areas - Those rivers or sections of rivers that are free of impoundments with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible.
- Recreational river areas - Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

In arriving at a finding of eligibility and stream classification, the study group had to exercise its judgment, not only for the eligibility criteria as it applied to the segment of river but on the river system as a whole, and to evaluate the combined effect of all criteria.

River Corridor Description

178. The portion of the Missouri River under study is located in the eastern portion of the States of Nebraska and South Dakota where it forms their mutual boundary. The river length in the study area is 59.05 miles and includes the area from immediately below Gavins Point Dam at the 1965 river mile 811.05 downstream to Ponca State Park, Nebraska, at 1965 river mile 752. The land adjacent to the river ranges from a relatively level flood plain to steep tree-covered bluffs on the Nebraska side and relatively level flood plain on the South Dakota side.

179. The river channel in this area remains essentially in a natural condition, unaltered by man; however, the river flow is regulated through the Gavins Point Dam. Flows during years of normal water

water supply vary seasonably between 35,000 cfs during the spring, summer, and fall months and 15,000 cfs or less during winter. The study reach is free from any impoundments and other structures which might impede flow. River banks vary from relatively flat sandy beach areas to vertical faces 10 to 15 feet high where active erosion is taking place.

VEGETATION

180. Natural vegetation along the study segment is composed primarily of two major plant communities. These are the flood plain forest of willow and cottonwood and the elm, oak woodland typical of the bluffs that border the flood plain in Nebraska.

181. Varying stages of flood plain vegetative succession are evident throughout the study segment. On the sand bars and newly deposited accretion lands adjacent to the river banks, the pioneer species of flood plain succession are evident. These include annual weeds, short-lived grasses, sedges, and seedling willow and cottonwood. Further back and higher above the water table larger willow and cottonwood trees dominate until finally a mature flood plain forest consisting mainly of cottonwoods on the highest banks and islands dominates the flood plain vegetation. Understory types in this mature cottonwood forest consist mainly of dogwood, sumac, wild grape, and poison ivy. Much of the mature cottonwood forest on the high banks adjacent to the river had been replaced with pasture and cultivated cropland, though remnant groves remain. These feature the most mature examples of this type forest. The two large islands in the river also support substantial groves of mature vegetation. Other examples of this plant community are seen on relatively new accretion lands and islands which have not been subject to agricultural development.

182. In contrast to this mixed flood plain forest and agriculture use on the flood plain are the hardwood forests of the adjoining

bluffs in Nebraska. There are several places in the study segment where the river flows at the base of the bluffs. Here, the bluffs and their hardwood forest dominate the scene. These slopes are predominantly north facing and support a very dense growth of oak, ash, mulberry, and walnut. Oak is by far the predominant species. Where grazing has been limited, a good understory shrub layer is present as in the flood plain forest. Dogwood and sumac are typical plants. This hardwood forest is predominant on the north-facing slopes and in the many draws and ravines of the bluffs. Near the hilltops where soil moisture is less abundant, and where there is a south or west exposure, the forest is replaced by native grasses mixed with yucca. The variety of vegetation types, contrasting with the flood plain forest, adds to the overall diversity of the study segment.

FISH AND WILDLIFE

183. An abundance of fish species can be found along the study corridor. The unchannelized condition of the river in the study reach provides a diversity of habitat for fish that was common throughout most of the Missouri River prior to its alteration by man. Although the main stem dam system has altered the river's traditional pattern of flow and significantly reduced its sediment load in this river reach, most of the indigenous fish species are still present. The changed river condition has, however, modified the dominance and abundance of species in the fish community, and there have been a few species introduced into the river. Table E-13 lists the principal fish species found in the national river reach today. Of these species, sauger, carp, channel catfish, goldeye, white bass and freshwater drum are the most abundant fish found in the fisherman's creel. A recent study shows that the Missouri River sport fishery compares favorably with other rivers in the United States, and the annual rates of catch and harvest were greater in the national river reach than any other portion of the river including the Gavins Point Dam tailwaters.

Table E-16 PRINCIPAL SPECIES OF THE FISH COMMUNITY FOUND IN THE RIVER STUDY REACH

Shovelnose Sturgeon 1/	Smallmouth Buffalo
Gizzard Shad 1/	Bigmouth Buffalo
Goldeye 1/	Shorthead Redhorse
Carp 1/	Flathead Catfish
River Carpsucker 1/	Walleye
Channel Catfish 1/	Freshwater Drum
Sauger 1/	Emerald Shiner
Paddlefish	Red Shiner
Shortnose Gar	Sand Shiner
Longnose Gar	White Bass
Blue Sucker	

1/ Indicates a dominance

184. The paddlefish, one of the oldest living fish, is found throughout the Missouri River drainage. However, its numbers are not great and known spawning grounds are few. It is felt that this lack of spawning areas has resulted because large portions of the river have been altered by man. The channelized river below Ponca State Park, for example, does not offer suitable spawning areas because water depths are too great and the bottom too uniform. Gavins Point Dam is a barrier to their movement upstream. The national river reach is, therefore, considered very important to the maintenance of the paddlefish in the Missouri River below Gavins Point Dam. Although there is no definite evidence of their spawning, paddlefish larvae were found in the river below Gavins Point Dam in the spring of 1976. This is the strongest evidence to date that paddlefish could be spawning in the study segment.

185. Wildlife in the study segment is fairly abundant although types of wildlife found have changed since the coming of the white man. Lewis and Clark, killed a buffalo and shot at two elk on

August 23, 1804, in what is now Dixon County, Nebraska; adjoining the national river reach. These species are not found in this area today, nor are plains grizzly bear and pronghorn antelope which were also dominate on the historic scene. A survey of this river reach identified one species of salamander, 14 species of frogs and toads, three species of lizards and 13 species of snakes. It is believed that this community of amphibians and reptiles has changed little in historic times. The abundance of the more completely terrestrial species of reptiles has probably diminished because of land use changes that have taken place.

186. The same survey accounted for 48 species of mammals. Small mammals, including mice, voles, bats, moles, rats, and ground squirrels, make up almost 60 percent of these species, and furbearers contribute another 20 percent. White-tailed deer is the only large mammal in the study segment; however, an occasional mule deer moves into the uplands adjoining the river from the west. Coyote, red fox and badger are also common to the reach. As with the reptiles, the species composition of the mammals has not changed significantly from historic times, except for the loss of the big herbivores and the grizzly bear. The community make-up, however, has been affected by the land use changes that have taken place.

187. The national river study corridor is the year-around home for 25 bird species. Fifty-eight species commonly nest in the area in addition to the year-around residents, while 15 additional species are common winter residents. Over 115 species regularly use the corridor on their spring migration and 110 return through the area during their fall migration. This number of species represents about one-third of the bird species that are present in the Missouri River Basin either as regular residents, common visitors, or as occasional visitors. Except for a few introduced species and a couple of recently extinct species there is very little change in the bird community from the historic past. The migration of

waterfowl and shorebirds along the national river study corridor remains one of the most important ornithological occurrances in the area. This is particularly true of their spring migration. The Interior Least Tern, a rare shorebird that is being studied for inclusion on the Federal endangered species list, is a regular, possibly common summer resident to the area. Breeding colonies use the clusters of sand bars that occur in the river between Vermillion, South Dakota, and Ponca State Park, Nebraska.

STREAMFLOW

188. The volume of water, as mentioned earlier, is influenced by releases from Gavins Point Dam. Water is released during the recreation season in amounts suitable to maintain commercial navigation at Sioux City, Iowa, the upper terminus of the Missouri River Bank Stabilization and Navigation Project. This seasonal release is at least 25,000 cfs, except during periods of flood discharge from the Floyd, Sioux, James, or other left-bank tributaries. These releases assure adequate flows for unimpeded recreation use.

189. Flows during years of normal water supply vary seasonally between 35,000 cfs during the spring, summer, and fall months, and 15,000 cfs or less during the winter. The study reach is free from any impoundments and other structures which might impede the flow.

WATER QUALITY

190. No water quality data measurements have been collected in this segment of the Missouri River except in the upstream reaches at Gavins Point Dam and Yankton, South Dakota. However, some water quality data have been collected near the mouth of the two major tributaries, the James River and Vermillion River. Specific information to identify any point source of water quality degradation which may be occurring within the reach is not available. It is generally assumed that the overall quality of the water is good with any degradating influences occurring further downstream in the

vicinity of Sioux City, Iowa. In the absence of specific water quality information, other sources of information were used to evaluate pollution potential and water quality in the subject reach. These sources included EPA-440/9-74-001, National Water Quality Inventory; EPA, Region VIII, Water Quality Inventory Executive Summary, 1975; and Missouri Tributaries River Basin Water Quality Management Plan, Nebraska Natural Resources Commission, November 1975.

191. The waters released from Gavins Point Dam generally comply with the requirements listed in the Federal Water Pollution Control Administration's Water Quality Criteria, dated April 1, 1968. The only exceptions are: (a) a slight exceedence of the optimal pH range of 6.5 to 8.3 SU; (b) mean phosphorus concentrations which are sufficient to support nuisance growth of aquatic organisms; and, (c) mean concentrations of cadmium which may exceed 1/500 of the 96-hour mean tolerance limit for aquatic habitat. However, this latter exception has not been supported by bioassay tests nor analysis of concentrations in fish flesh. It is based on a comparison of measured concentrations to specific acceptable levels published in more recent water quality criteria. Each of the listed exceptions appear to be of natural origin and would probably not be reduced by any additional upstream regulation. It is not expected that these exceptions would interfere with classification of the subject reach for National Recreation River status.

192. The inflows from the James and Vermillion Rivers have occasional high measured levels of fecal coliforms. However, a statistical analysis of these tributary loadings shows that there is less than a one percent probability that the tributary inflows will increase fecal coliform levels in the Missouri River above the standard of 200 mpn/100 ml. This analysis assumed a background fecal coliform loading in the Missouri River of 12 mpn/100 ml (average fecal coliform level at Yankton, South Dakota), and that all other point and non-point loadings in the subject reach are

inconsequential. All other possible pollutional effects of these tributary inflows on the Missouri River are considered minor. Based on this assessment, it appears that the pollutional loadings from the James and Vermillion Rivers should not cause sufficient water quality degradation in the Missouri River to limit its use for primary contact recreation.

193. Other possible pollution sources within the reach include wastewater effluent, feedlot runoff, and other non-point agricultural runoff. The major wastewater facilities in the subject reach are at Yankton and Vermillion, South Dakota. Both cities now have secondary treatment. As such, pollution from wastewater effluent should not be a problem. The basin management plan prepared by the State of Nebraska indicates that approximately 28,000 head of cattle are being fed in feedlots within the right bank drainage area of the subject reach. Information on feedlots in the South Dakota drainage is not available. Pollution entering the Missouri River from this source should also be fairly well controlled in the future because of Federal requirements on the States under the auspices of PL 92-500. The last source, non-point agricultural runoff, is currently an unregulated pollution source. The major agricultural land use in the area is row crops. Row crops are generally more polluting than other farming practices because of higher rates of soil erosion with consequential losses of applied nutrients and pesticides. The impact of this source, and the residual pollution from the other two regulated sources, on the quality of the Missouri River through the subject reach cannot be determined at this time.

194. Water Quality Standards established by both Nebraska and South Dakota state that the waters shall be maintained suitable for primary contact recreation and warm water fish life propagation. However, the requirements of these Standards can only be applied to controllable pollution sources, of which a possible major source, non-point agricultural land use, is not currently included. At the

present, there is no reason to suppose that contact recreation might be limited anywhere except perhaps near the James and Vermillion Rivers.

Public Access

195. Public access along this stretch of the river is limited. It varies from areas having little or no facility development to fully developed boating and camping areas. These areas are owned and operated by the Federal Government, as well as State, county, and city governments.

- FEDERAL LAND

  Federal lands on this river reach consist of lands immediately below the Gavins Point Dam on both the South Dakota and Nebraska sides. On either side there are facilities for boating, camping, picnicking, and shoreline fishing. On the South Dakota side, in the old river channel, a swim beach is provided in addition to the other facilities.

- STATE LAND

  SOUTH DAKOTA: The South Dakota Game, Fish and Parks Department owns and manages eight parcels of land along the river making up a total of 963 acres. With the exception of Clay County State Recreation Area, these lands are primarily set aside as game production areas. Recreational facilities, such as boat ramps or river access points, are available at most of these areas. Another access to this reach of the river, although not directly on the Missouri, is located at Kelly Cove on the James River, two miles upstream from its confluence with the Missouri. This site provides access by way of the James River. The State may also have title to some accretion lands on the South Dakota side of the river.

  NEBRASKA: The Nebraska Game and Parks Commission owns Ponca State Park (836 acres) located 60 miles downstream from Gavins Point Dam. This State park consists mainly of the forested bluffs, with some accretion land at their base where fishing and boating access is available. Facilities here include a boat-launching area, camp pads, picnic facilities, cabins, and a variety of other recreation facilities.

- COUNTY LAND

  SOUTH DAKOTA: The three counties located in South Dakota have no known public access to the river.

  NEBRASKA: Of the two counties on the Nebraska side, only Cedar County offers public access to the river. It has two boat ramps, one in the Cedar County Park, 11 miles downstream from Gavins Point Dam, and the other on private land at the Sportsmans Steak House, 25 miles downstream from Gavins Point Dam. This boat ramp was constructed on privately-owned land by the county through an agreement with the landowner and is available for public use.

- CITY-OWNED LAND

  Yankton, South Dakota, owns approximately one-half mile of the town's riverfront land, as well as two parcels of land on either side of the Highway 81 bridge on the Nebraska side of the river. The riverfront land in town is used for municipal purposes such as the water and sewage plants, as well as for public access. Public recreation facilities include a boat ramp, picnic tables and shelters, a playground, and ball diamonds. On the Nebraska side, the City of Yankton owns two timbered areas which have no development. One is located on each side of the bridge. Access is attainable to the river's edge across trails in these two areas.

- OTHER

  In Cedar County, Nebraska, two short stretches of county road parallel the river, 24 and 27 miles downstream of the dam, the only area where a road closely parallels the river. One county road and several private roads lead to and dead end at the river. However, the private roads provide no public access for river use. Lands adjacent to these roads are privately owned.

Adjacent Land Use

196. The major use of the land adjacent to the river is for agricultural purposes. These include uses for both irrigated and non-irrigated crops and for pasture. The predominant use of these lands at the current time is for cultivated crops. According to a survey done by the Corps, 75-95 percent of the lands immediately adjacent to the river are used for crops. Corn is the most important of these, followed by soybeans, alfalfa, and oats. Pasture makes up 5-10 percent of the land and the remainder is in woodlots. Other lands along the river banks and within the river itself include sand dunes, bars, and islands which support varying stages of vegetative growth ranging from grasses to flood plain cottonwood forest.

197. Interspersed in this generally agricultural area are individual homes, clusters of homes, and public recreation and wildlife lands. Immediately adjacent to the river banks, residential uses include the City of Yankton, South Dakota. Cabins, trailers, and clusters of both are located sporadically along the river banks in both states. Their nature and location are shown on Table E-17.

Historical and Cultural Areas

198. Eight historic sites and two archaeologic sites, listed in the National Register of Historic Places are located along the study corridor, as listed in Table E-18 and shown on Figure E-21. All of these were listed in the National Register of Historic Places as of December 31, 1974, and are within the 10-mile (16.1 km) study corridor.

Table E-17 STRUCTURES AND INTRUSIONS - MISSOURI RIVER GAVINS POINT TO PONCA STATE PARK

Item	Mile	Bank	Trailers	Docks	Irri-gation Pumps	Road or Dug Ramp	Cabins (includes houses)	Car Bodies (Bank Protection)
Boat Dock & Stairs	751.2	R	-	1	-	-	-	-
Boat Dock & Stairs	751.22	R	-	1	-	-	-	-
Dock	751.4	R	-	1	-	1	-	-
Rock (gravel) fill	752.1	R	-	-	-	-	-	-
Floating Dock	752.1	R	-	1	-	-	-	-
Old Concrete Pier (horse) (pipeline)	753.5	L	-	-	-	-	-	-
Ponca State Park Ramp	753.5	R	-	-	-	1	-	-
Cabin	758.0	-	-	-	-	-	1	-
Floating Dock	760.0	R	-	1	-	1	1	-
Cabin	762.0	R	-	-	1	-	1	-
Car Bodies	763.0	R	-	-	-	-	1	9
Ramp	763.4	L	-	-	1	1	-	-
Trailer	763.5	R	1	-	-	-	-	-
Trailers	765.0	R	2	-	-	-	-	-
Car Bodies	768.4	L	-	-	-	-	-	2
Cabin	768.5	R	-	-	-	-	1	-
Cabin	768.5	L	-	-	-	-	1	-
Cabin	768.6	L	-	-	-	-	1	-
Floating Dock, Cabin	768.7	L	-	1	-	1	1	-
Dock, Stairs, Cabin	768.75	L	-	1	-	-	3	-
Floating Dock, Stairs	769.1	L	-	1	-	-	-	-
Floating Dock, Stairs, Cabin	769.3	L	-	1	-	-	1	-
Dock, Cabin	769.32	L	-	1	-	-	1	-
Ramp, Docks, Fuel Tank	769.4	L	-	2	-	1	-	-
Trailer	771.0	L	1	-	-	-	-	-
House	771.5	L	-	-	-	-	1	-
Trailer	772.0	L	1	-	-	-	-	-
Trailer	772.1	L	1	-	-	-	-	-
Floating Dock, etc	772.2	L	1	1	-	-	-	-
Floating Dock, etc.	775.9	R	1	1	-	1	1	-
Ramp	781.0	L	-	-	-	1	-	-
Irrigation Pump	781.1	R	-	-	1	-	-	-
Floating Dock	782.3	R	-	1	-	-	-	-
Floating Dock	782.5	R	1	1	-	-	1	-
Trailers, Cabins	782.6	R	2	-	-	-	4	-
Floating Dock	782.7	R	-	1	-	1	1	-
Docks, etc	782.7	L	-	2	-	1	1	-
Rubble Hard Points	782.75	L	-	-	-	-	-	-
Dug Ramp	782.8	R	-	-	-	1	-	-
Floating Dock & Stairs	782.8	L	5	1	-	-	-	-
Floating Dock, Stairs	782.85	L	-	1	-	-	-	-
Floating Dock	782.9	L	-	1	-	-	1	-
Junk	782.9	R	3	-	-	-	-	-
House	782.95	R	-	-	-	-	1	-
Floating Dock & Stairs	782.95	L	-	1	-	-	1	-
Floating Dock & Stairs	782.96	L	-	1	-	-	1	-
Tower, Fl Dock, Rubble Hard Pt	782.97	L	-	1	-	-	1	-
Tower, Floating Dock	782.95	R	-	1	-	1	1	-
Cars & Cabins	783.0	R	-	-	-	-	2	1
Cabins & Fill	783.0	L	-	-	-	-	2	-
Floating Dock	783.05	L	-	1	-	1	1	-
Floating Dock & Stairs	783.1	L	-	1	-	-	1	-
Rubble Bank Protection	783.15	L	5	-	-	-	2	-
Car Bodies on Bank	783.5	L	-	-	-	-	-	17
Steel Pile Dikes	783.5	R	1	-	-	-	-	-
Junk	783.7	L	-	-	-	-	-	-
Floating Dock & Cabin	783.75	R	-	1	-	1	1	-
Ramp	783.8	R	-	-	-	1	-	-
Ramp, Dock, Trailer	783.85	R	1	1	-	1	1	-
Ramp,	783.9	R	-	-	-	1	-	-
Ramp, Cabins, Car Bodies	784.8	R	-	1	-	1	2	2
Fl Dock, Trailers, Cabins, Junk	784.2-25	L	4	1	-	1	2	-
Floating Dock & Ramp	784.85	L	-	1	-	1	1	-
Ramp & Stairs, Cabin	784.9	L	-	-	-	1	1	-
Floating Dock, Trailers, Cabins	784.95	L	3	1	-	-	1(modular)	-
House	785.0	L	-	-	-	-	1	-
Ramp, Trailer, Cabin	785.1	R	1(Bus)	-	-	1	1	-
Ramp & Cabin	785.35	R	-	-	-	1	1	-
Ramp	785.4	R	-	-	-	1	-	-
Ramp & Trailer	785.45	R	1	-	-	1	-	-
Junk	785.5	L	-	-	-	-	-	-
Ramp, Dock, Cabins	785.5	R	-	1	-	1	2	-
Ramp & Trailer	785.6	R	2	-	-	1	-	-
Ramp & Cabin	785.7	R	-	-	-	1	1	-
Ramp & Cabin	785.9	L	-	-	1	-	1	-

Table E-17 (Cont'd)

Item	Mile	Bank	Trailers	Docks	Irrigation Pumps	Road or Dug Ramp	Cabins (includes houses)	Car Bodies (Bank Protection)
Floating Dock, Stairs & Trailer	786.05	L	1	1	-	-	-	-
Floating Dock, Stairs & Cabin	786.1	L	-	1	-	-	1	-
Floating Dock, Stairs & Cabin	786.15	L	-	1	-	-	1	-
Cabin	786.15	R	-	1	-	-	2	-
Floating Dock, Stairs & Cabins	786.25	L	-	1	-	-	1	-
Cabins	786.5	L	-	-	-	-	2	-
Ramps & Piles, Trailers & Cabins	786.7	R	5	1	-	1	2	1
Floating Dock, Stairs & Cabin	786.75	L	-	1	-	-	1	-
Floating Dock, Stairs & Cabin	786.75	R	-	1	-	-	1	-
Cabin	787.0	R	-	-	-	-	1	-
Ramp & Turnaround, Cabin	787.02	L	-	-	-	1	1	-
Cabin	787.1	L	-	-	-	-	1	-
Car Bodies on Bank	789.8	L	-	-	-	-	-	20
Junk	790.6	L	-	-	-	-	-	1
Cabin & Trailer	794.4	R	1	-	-	-	1	-
Cabin	794.5	R	-	-	-	-	1	-
Floating Dock & Trailers	796.1	L	2	2	-	-	-	-
Dock, Trailers, Cabin	796.15	L	2	1	-	-	1	-
Junk	796.25	L	-	-	-	-	-	2
Rubble on Bank	796.8	L	-	-	-	-	-	-
Cars & Junk	796.8	L	-	-	-	-	-	10
Dike	797.0	L	-	-	1	-	-	-
Irrigation Pump	797.5	L	-	-	1	-	-	-
Ramp	797.5	R	-	-	-	1	-	-
Car Bodies	798.25	L	-	-	-	-	-	4
Car Bodies	798.3	L	-	-	1	-	-	3
Floating Dock & Walk	798.35	L	-	1	-	-	-	-
Car Bodies	798.5	L	-	-	-	-	-	12
Ramp	798.5	R	-	-	-	1	-	-
Irrigation Pump	798.7	L	-	-	1	-	-	-
Fl Docks, Trailer & Cabin	801.4	L	1	2	-	-	2	-
Car Bodies & Junk	802.4	L	-	-	-	-	-	7
Car Bodies	802.5	L	-	-	-	-	-	11
Trailer, Cabin, Car Bodies	803.0	R	4	-	-	-	1	2
Ramp	803.5	L	-	-	1	1	-	-
Fill	805.0	R	-	-	-	-	-	-
Outfall & Rubble	805.2	L	-	-	-	-	Buildings	-
Fill	805.25	L	-	-	-	-	Buildings	-
Floating Dock & Stairs	805.3	L	-	1	-	-	-	-
Dike, Rubble & Stairs	805.4	L	-	1	-	-	-	-
Riverside Park	805.6	L	-	1	-	1	Buildings	-
Irrigation Intake, Boathouse	806.0	L	-	1	1	-	Buildings	-
Floating Dock, Stairs & Cabin	806.2	L	-	1	-	-	1	-
Dock	806.3	L	-	1	-	-	-	-
Boathouse & Stairs	806.4	L	-	-	-	-	-	-
Docks & Stairs	806.5	L	-	1	-	-	Buildings	-
Dock	806.6	L	-	1	-	-	-	-
Dock & Cabin	806.7	L	-	1	-	-	1	-
Dock, Stairs & Cabin	806.75	L	-	1	-	-	1	-
Dock	806.85	L	-	1	-	-	-	-
Dock & Stairs	806.9	L	-	1	-	-	Buildings	-
Dock & Stairs	807.0	L	-	1	-	-	1	-
Car Bodies & Junk	807.2	L	-	-	-	-	-	15
Car Bodies & Junk	807.3	L	-	-	-	-	-	50
Car Bodies & Junk	807.5	L	-	-	-	-	-	15
Car Bodies & Junk	807.55	L	-	-	-	-	-	10
Car Bodies & Pile Dikes	807.6	R	-	-	-	-	-	6
Log & Tree Fill	807.7	R	-	-	-	-	-	-
Docks, Trailers & Cabins	807.8	R	3	5	-	-	1	-
Docks, Trailers & Cabins	808.0	R	10	5	-	1	1	-
Dock, Stairs & Trailers	808.1	R	3	1	-	-	-	-
Dock, Stairs & Trailers	808.5	R	2	1	-	-	-	-
Marina	808.9	R	-	1	-	1	Buildings	-
Ramp & Cabin	808.9	L	-	Boathouse	-	1	1	-
Floating Dock & Cabin	809.4	L	-	1	-	-	1	-
Rubble, Hard Point Fill & Cabin	809.5	L	-	-	-	-	1	-
Dock & Boathouse	809.6	L	-	1	-	-	Buildings	-
Retainer Wall, Dock & Boathouse	809.7	L	-	1	-	-	1	-
Car Bodies	809.8	L	-	-	-	-	-	16
Dock, Rubble Fill	809.85	L	-	1	-	-	-	-
Government Ramp	810.05	L	-	-	-	1	-	-
Government Ramp	810.3	R	-	-	-	1	-	-

Table E-18 SITES IN NATIONAL REGISTER OR HISTORIC PLACES IN SOUTH DAKOTA AND NEBRASKA

SOUTH DAKOTA

Clay County

1. Austin-Whittemore Museum
2. Old Main
3. Spirit Mound

Yankton County

4. Bishop Marty Rectory

NEBRASKA

Dixon County

5. Cook Blacksmith Shop

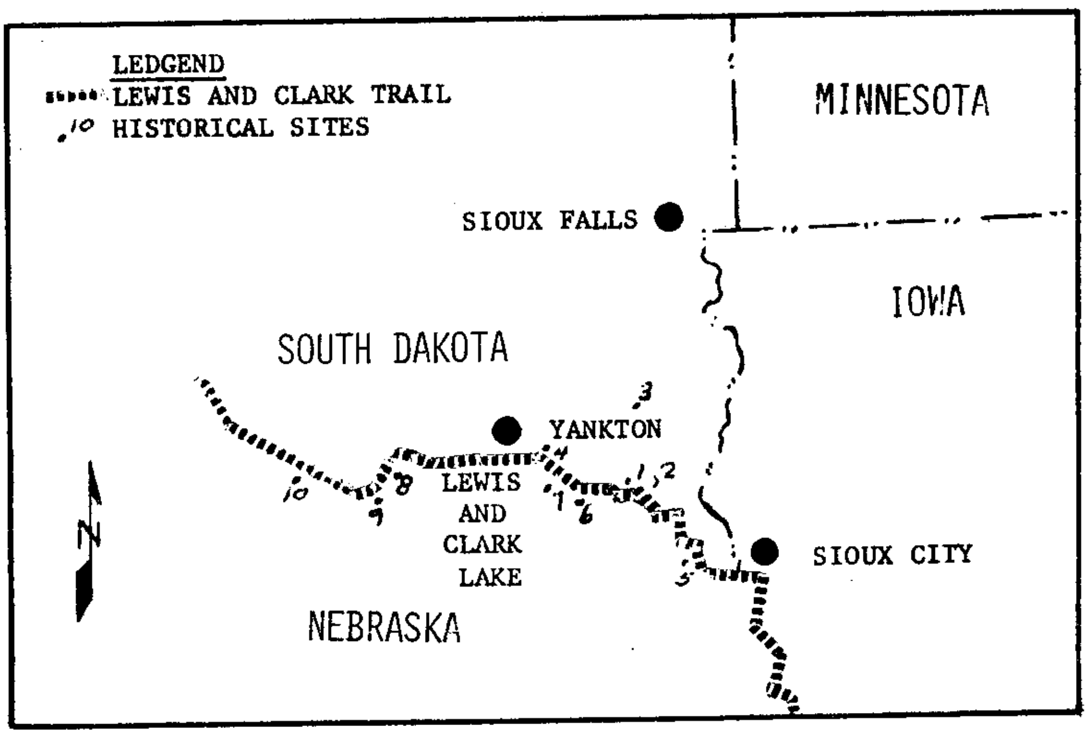
Cedar County

6. Wiseman Archaeological Site
7. Schulte Archaeological Site

Knox County

8. Episcopal Church
9. Congregational Church & Manse
10. Ponca Fort Site

Figure E-21 LEWIS AND CLARK TRAIL AND HISTORICAL SITES



199. The Missouri River is rich in history, having been a natural highway and a focal point for occupation throughout history. The Missouri River corridor was the route of explorers Lewis and Clark, Indian traders, trappers, and pioneers as they traveled toward the Rocky Mountains. Its role in the settlement of the trans-Mississippi west was very significant and many features and sites of historical importance can still be seen along it. The route of the 1804-1806 Lewis and Clark Expedition has been studied by the Bureau of Outdoor Recreation and will be recommended for designation as a National Historic Trail.

200. Evidence of Indian inhabitants can be found at several locations along this segment of the river. An earth lodge village site is located on the bluff above Bow Creek in Cedar County, Nebraska. This site was first recorded by Lewis and Clark as they traveled up the Missouri River in August, 1804. Other archaeological sites identified in this segment but whose significance is unknown include burial mounds, a burial site, and an occupational site in the same general area of Cedar County, Nebraska.

201. The earliest major historical documentations of the river are the journals kept by Lewis and Clark as they made their epic journey up the Missouri in 1804 and 1805, and returned in 1806.

202. Information from the Lewis and Clark journal indicates that they camped on this particular segment of the river eight times in the process of their round trip. Six campsites were made during the period August 23 - August 31, 1804, on the way up river and two on September 1 and September 2, 1806, as they returned to St. Louis.

203. In their journals, Lewis and Clark described the surrounding countryside as they traveled upstream. They mention the rivers

which flow into the Missouri in this segment, the bluffs, the sand bars, islands, and wildlife. The landscape remains much today as it was then. Significant features are still identifiable. One feature mentioned in the Lewis and Clark journal, and which was to become a local landmark, was the Ionia 'volcano.' The journal describes it as a "burning bank or bluff which was very high and had fire in it . . . . ." This bluff they reported as located opposite the Whitestone River, the present-day Vermillion River. The Indians of the area thought of this hill as being associated with the supernatural and regarded it with awe.

204. Thousands of river travelers and settlers saw this hill and wondered at the "burning bluffs." Most of them believed it was a volcano. During the 1860's and 1870's the Ionia 'volcano' attracted much attention, especially when increased subterranean activity followed the frequent floods on the Missouri River. High water caused chemicals in the hill to react and caused steam and sulfurous fumes to rise from the cracks in the hills. Local residents feared a volcanic eruption. On November 15, 1877, an earthquake in northeast Nebraska was thought to be an impending eruption of Ionia 'volcano.' Early in 1878, a raging flood on the Missouri severely damaged the small town of Ionia, from which the bluff got its name, and washed away a large section of the hill. The river now flows some distance from the base of the bluff, so it no longer releases steam and gases. All that remains of the town of Ionia which was relocated up the bluff is a cemetery and the foundation of a school. This is one of the several prominent features still identifiable.

205. Calumet Bluff, site of Gavins Point Dam, was the location of a Lewis and Clark campsite from August 28 - August 31, 1804, while they met with the Sioux Indians of this region. This bluff, too, was a well-known landmark. The exact location of other Lewis and Clark campsites located along the river would be almost impossible to determine precisely, since the river channel has changed so much

since 1804; nevertheless, the approximate locations can be determined. Indian traders and trappers followed soon after Lewis and Clark, and the era of steamboats on the Missouri began a few years later. By 1831, the steamers had traveled well beyond Gavins Point. It was in this year that the steamer Yellowstone reached Fort Pierre, South Dakota. Both sidewheelers and sternwheelers traveled this portion of the river. Some became victims of the river either because of snags, ice, or fire. In this segment of the river there were at least seven steamboat wrecks. By 1900, steamboat travel on the Missouri was essentially a thing of the past.

Recreation

206. Because of its nearness to major population centers, its areas of accessibility, and its availability for year-round recreational use, this segment of the Missouri River is a major recreational resource. As a result, developed sites have become increasingly popular along most of the segment.

207. At present, the upper reach of this segment, the area just below Gavins Point Dam, supports the heaviest recreational use. It contains two major campgrounds having approximately 172 camp pads, a large lighted fishing pier, approximately one mile of shoreline for fishing, a 300-foot beach, and three boat ramps. All these facilities are located on land administered by the Corps of Engineers.

208. Downstream from Gavins Point Dam, recreational use decreases due to the decreasing amount of recreational facility development and access points along the river. However, the South Dakota Game, Fish and Parks Department and the Nebraska Game and Parks Commission own parcels of land of recreational significance along this segment of the Missouri River, the most important areas of these being Ponca State Park, Nebraska, and Clay County State Recreation Area, South Dakota.

209. The South Dakota Game, Fish and Parks Department owns several

parcels of land along the river which are set aside as game production areas. One is located in the Audubon Bend area, 23 miles downstream from Gavins Point Dam. This area of about 80 acres is mostly timber, but also has a small boat-launching area at a road end. About 32 miles downstream, another State area is located on the river. This area has no boat-launching facilities and is mostly in timber. In Union County, the Department owns another game production area. This is located 46 miles downstream of the Gavins Point Dam at Bolton Bend. Also in Union County the Department owns the Clay County State Recreation Area. This park contains about ten campspaces and picnicking and boat-launching facilities. The Department also owns land providing public river access at Kelly Cove on the James River about two miles upstream from its confluence with the Missouri.

210. The State of Nebraska Game and Parks Commission owns Ponca State Park at the downstream end of the study area, 54 miles downstream from Gavins Point Dam. This State park consists of 836 acres, mainly of the forested bluffs in the area, with some accretion land at their base where fishing and boating access is available. Facilities here include a boat-launching area, approximately 300 camp pads, picnic facilities, cabins, a large swimming pool, and a variety of other recreation facilities.

211. County- and city-owned land makes up the remainder of the public access to this segment of the Missouri River. Cedar County, Nebraska, offers public access to two locations. It has two boat ramps, one in the Cedar County Park, 11 miles downstream from Gavins Point Dam, and the other on private land at the Sportsmans Steak House 25 miles downstream from Gavins Point Dam. This boat ramp was constructed by the county through an agreement with the landowner and is available for public use.

212. The riverfront land owned by the City of Yankton, South Dakota is used mainly for municipal purposes such as water and sewage

treatment plants; however, public recreation facilities are included. The facilities include a boat ramp, picnic tables and shelters, a playground, and ball diamonds.

213. Current (1976) estimates of recreation use indicate a total of about 950,000 recreation-days along this segment of the river. Swimming and fishing constitute the major uses, with 298,000 and 214,000 recreation-days, respectively. Camping accounts for about 129,000 recreation-days, while hunting, picnicking, boating, and canoeing account for an additional 309,000 recreation-days in total.

The Classification Process

214. After gathering relevant data on the study segment of the Missouri River, the Study Team determined potential suitability in the following ways:

- First, the segment was evaluated in terms of its eligibility for inclusion in the National System;
- Next, the classification (wild, scenic, or recreational) which best describes the existing condition of the river segment was determined; and
- Finally, inputs from the public were evaluated.

The Wild and Scenic Rivers Act contains the basic criteria for rivers or segments of rivers that are being considered for inclusion in the National System. They must be free flowing and possess one or more outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values.

ELIGIBILITY CRITERIA

215. Basic criteria in the Wild and Scenic Rivers Act are supplemented by the 1970 Guidelines (Appendix A). Pages 2-5 of that paper spell out the general characteristics of rivers to be included in the system, and outline the approach to be taken in evaluating them. For the Missouri, the most important of these are:

- Free flowing: "Without impoundment, diversion, straightening, ripraping, or other modification of the waterway. However, low dams, diversion works, and other minor structures will not automatically preclude the river unit from being included . . . ."

● Water Volume: "There should be sufficient volume of water during normal years to permit, during the recreation season, full enjoyment of water-related outdoor recreation activities generally associated with comparable rivers. In the event the existing supply of water is inadequate, it would be necessary to show that additional water can be provided reasonably and economically without unreasonably diminishing the scenic, recreational, and fish and wildlife values of the area."

● Length: "The river or river unit must be long enough to provide a meaningful experience. Generally, any unit included in the system should be at least 25 miles long."

● Water Quality: "The river should be of high quality water or susceptible of restoration of that condition."

● Outstandingly Remarkable Qualities: No definition offered.

● Methodology: "The investigator has to exercise his judgment, not only on the specific criteria as they apply to a particular river, but on the river as a whole, and on their relative weights. For this reason, these guidelines are not absolutes. They may be extenuating circumstances which would lead the appropriate Secretary to recommend . . . . a river for inclusion in the system because it is exceptional in character and outstandingly remarkable even though it does not meet each of the criteria set forth in these guidelines."

ELIGIBILITY OF THE MISSOURI RIVER

216. Table E-19 summarizes the results of comparing the river's characteristics with the above definitions.

Table E-19 SUMMARY OF ELIGIBILITY, MISSOURI RIVER SEGMENT

Characteristics	Gavins Point Dam to Ponca State Park
Free-flowing Nature Affected by	
Impoundments	None
Diversions	None
Road Fills	None
Bank Stabilizations	Several
Length	59.05 1/
Water Quality Meets Criteria for:	
Primary Contact Recreation	Yes
Secondary Contact Recreation	Yes
Water Esthetics	Yes
Fish and Aquatic Life Propagation	Yes
Outstandingly Remarkable Values	
Scenic	No
Recreation	Yes
Geologic	No
Fish and Wildlife	Yes
Historic and Archaeologic	Yes
Cultural	Yes
Eligibility For National Wild and Scenic Rivers System	Eligible

1/ 1965 river mile 811.05 just below Gavins Point Dam to 1965 river mile 752 just above Champlin pipeline at Ponca State Park - 59.05 miles.

CRITERIA FOR SETTING CLASSIFICATION LEVELS

217. Paragraph E-177 gave the classification categories available for eligible streams. The following criteria are summarized from the "Guidelines for Evaluating Wild, Scenic, and Recreation River Areas proposed under Section 2, Public Law 90-542." These were used

to determine the classification eligibility of the various river segments.

● Wild: 1. Flow - Free flowing. Low dams, diversion works or other minor structures which do not inundate the natural riverbank may not bar consideration as wild. Future construction restricted.

2. Accessibility - Generally inaccessible by road. No roads in narrow, incised valley. If broad valley, no road within 1/4 mile of riverbank. One or two inconspicuous roads to the area may be permissible.

3. Shorelines - Shorelines essentially primitive. One or two inconspicuous dwellings, limited amount of domestic livestock, and land devoted to production of hay may be permitted. Watershed natural-like in appearance.

4. Water Quality - Water quality meets minimum criteria for primary contact recreation except where such criteria could be exceeded by natural background conditions and capable of supporting propagation of aquatic life normally adapted to habitat of the stream.

● Scenic: 1. Flow - Free flowing. Low dams, diversion works or other minor structures which do not inundate the natural riverbank may not bar consideration. Future construction restricted.

2. Accessibility - Accessible by roads which may occasionally bridge the river area. Short stretches of conspicuous and well-screened roads or railroads paralleling river area may be permitted, but consider type of road use.

3. Shoreline - Shoreline and immediate river environs still have overall natural character. Small communities limited to short reaches of total area. Agricultural practices which do not adversely affect river area may be permitted. This could include unobtrusive row crops and timber harvest.

4. Water Quality - Water quality should meet minimum criteria for desired types of recreation except where such criteria would be exceeded by natural background conditions and capable of

supporting propagation of aquatic life normally adapted to habitat of the stream, or is capable of and is being restored to that quality.

● Recreational: 1. Flow - May have undergone some impoundment or diversion in the past. Water should not have characteristics of an impoundment for any significant distance. Future construction restricted.

2. Accessibility - Readily accessible, with likelihood of paralleling roads or railroads along riverbanks and bridge crossings.

3. Shoreline - Some shoreline development. May include all agricultural uses, small communities, or dispersed or clustered residential.

4. Water Quality - Should meet minimum criteria for desired types of recreation except where such criteria would be exceeded by natural background conditions and capable of supporting propagation of aquatic life normally adapted to habitat of the stream, or is capable of and is being restored to that quality.

● No Classification: Segment does not meet minimum general characteristics and one or more specific criteria described in the evaluation "guidelines."

Classification of the Gavins Point-Ponca Reach

218. Application of the classification procedures discussed in the preceding four paragraphs to the physical data pertaining to the study reach resulted in the following evaluation of major attributes:

● Flow: Regulated by mainstream dams above this river reach relatively slow; sufficient for all types of water related recreation. Slow flow permits appreciation of river's outstanding attributes.

● Accessibility: Limited; major areas for access are Corps of Engineers area below Gavins Point Dam, Clay County State Recreation Area, and Ponca State Park. Several other small areas available.

● Shoreline: Broad valley floor is bordered by bluff lines which meander from forming the high bank line to as far as several miles from the river; one major town, Yankton, South Dakota, abuts the river; sporadic recreational habitations intersperse the segment; agricultural lands with farm facilities dominate bottomlands; cottonwoods, willows, and shrubs line the stream course; hardwoods occur in bluff areas.

- Water Quality: Several minor pollution sources from bordering habitations; suited for recreation activities and propagation of normal aquatic life.

219. The most protective classification for which the Gavins Point to Ponca State Park reach is eligible, based on existing conditions, was that of RECREATIONAL RIVER AREA. The segment did not meet eligibility for SCENIC classification due to the extensive shoreline intrusions identified in Table E-17 and to the absence of outstanding scenic values. The reach did, however, merit more protection than that provided by the other alternative considered: NON-CLASSIFICATION.

Public Input

220. An important part of this study effort was to solicit and obtain public input. In pursuit of this goal two Umbrella Study public meetings were held. The first was held on June 31, 1976, in Pierre, South Dakota, the second on July 1, 1976, in Yankton, South Dakota. Comments received during and after these meetings were generally supportive of studying this segment of the Missouri River for possible inclusion in the National Wild and Scenic Rivers System. Verbatim transcripts of these comments are on file with the Corps of Engineers.

Analysis of Alternatives

221. The Water Resources Council developed and tested an analytical procedure for comparing and displaying beneficial and adverse effects of alternative water and land resource development plans in 1971. The process was first known as the multi-objective planning process since alternative plans for four, often conflicting objectives were developed.

The process was substantially modified and finally adopted by Executive Order as the "Principles and Standards for Planning Water and Related Land Resources" (Federal Register, Volume 38, No. 174, September 10, 1973). This procedure is prescribed for all agencies of the Federal Executive Branch during formulation of all water resource development projects, including free-flowing river studies. This section describes the results of such analysis of three alternative plans for the Missouri River segment found eligible for inclusion in the National Wild and Scenic Rivers System. A complete step-by-step description of the Principles and Standards analysis is included in Section D.

PURPOSE

222. The analysis is intended to provide decisionmakers with a better basis for determining whether or not the eligible Missouri River segment should be made a part of the National Wild and Scenic Rivers System. This section describes and quantifies, to the extent possible, the beneficial and adverse effects of each of three alternative plans. Both monetary and non-monetary effects are considered. The first plan is a "No Action" plan, and it reflects a continuation of current land and water use and management. The second plan, referred to as Plan A, reflects designation of the 59.05-mile segment of the Missouri River under the National Wild and Scenic Rivers Act. The third plan, referred to as Plan B, would provide additional recreation access and development for this segment of the Missouri River without designation as a component of the National Wild and Scenic Rivers System. Each plan is compared to the "No Action" plan and additional impacts, as well as total effects, are given for these alternatives.

NO ACTION PLAN

223. This plan involves Federal, State, and local agencies. It assumes that current trends in the use and development of resources will continue and that no new action will be taken as a result of

this study. Farming and recreation will continue to be the predominant activities along this segment of the Missouri River. The intensity of some of these uses, especially recreation, subdivisions for vacation homes, and protection of the high banks to reduce erosion losses, is expected to increase in some segments.

224. A major portion of this river segment is in private ownership as previously noted. A high potential exists for subdivisions in development of vacation homes, especially near Yankton and Vermillion, South Dakota.

225. Continuation of high bank erosion control is expected to continue under this alternative. Both Federal and non-Federal erosion control measures are assumed to continue throughout this reach to protect both agricultural lands and recreational home development land. The methods used under this plan would be those that are most cost-effective and not necessarily compatible with those required in Plan A, which considers inclusion in the National Wild and Scenic Rivers System. Also, it is assumed that no measures will be taken to protect instream islands and sand bars which are an integral environmental resource on this segment of the Missouri River.

ECONOMIC AND REGIONAL DEVELOPMENT IMPACTS OF NO ACTION

226. Present yields from croplands will increase slightly. This is due to the expected continuation of clearing woodlots for agricultural purposes. Most farms in the river area are stable and provide a major source of economic value in the area.

227. Recreation use in the Recreation Market Area (RMA) (those counties surrounding the 59.05-mile segment of the Missouri River being studied) has been increasing over the past years. Modest increases in the recreational use are anticipated due to increasing population in the RMA. Most use would continue to occur on the developed Corps of Engineers' sites at Gavins Point Dam and Lewis and

Clark Lake, as well as Nebraska's Ponca State Park. Continued use of this segment is also anticipated by boaters coming up-river from the Sioux City area. No future major recreation developments are anticipated under this alternative. By 1990, about 1,000,000 recreation-days use are expected to occur annually. The value of this use is estimated to be about $1,940,000, based upon an evaluation of the weighted average worth of a current recreation day ($1.94).

SOCIAL IMPACTS OF NO ACTION

228. The No Action plan will have minimal effect on individuals in this Missouri River area. Little change in land use is expected, and growth of the area will be modest. Agriculture and recreation will increase. The major economic activity will continue to be agriculture.

229. The shoreline will continue to undergo erosion and this, in turn, will lead to further erosion control measures. Loss of woodlots along the bank will continue due to agricultural practice. Historic and archaeological sites on private lands would not receive additional protection and could be degraded.

PLAN A - DESIGNATION AND DEVELOPMENT AS A RECREATIONAL RIVER

230. Under this plan the 59.05-mile main stem of the Missouri River from 1965 river mile 811.05 below Gavins Point Dam to 1965 river mile 752 at Ponca State Park would receive RECREATIONAL classification and protection under the Wild and Scenic Rivers Act, as amended. Resource value protection would be achieved primarily through scenic and recreational use easements. If this plan were implemented, approximately 14,500 acres would be protected by easements. Fee title acquisition of private lands would total 424 acres, primarily for public access and recreation development, as discussed in paragraph E-267.

ENVIRONMENTAL AND LAND USE IMPACTS OF PLAN A

231. This alternative would protect the warm water fishery habitat and would ensure protection of the major islands, sand bars, and woodlots critical for wildlife and waterfowl habitat. Future man-made development or structures along this stretch of river would be strictly limited under the terms of the Wild and Scenic Rivers Act. Agricultural land would not be affected, although further encroachment to the river's shoreline would be restricted and use of the islands for agricultural production would be restricted.

RECREATION COSTS AND BENEFITS OF PLAN A

232. Elements of this plan to accommodate public use of this reach of the river includes acquisition of 424 acres of land in fee and construction of sanitary, river access, and camping facilities. In addition, existing river access facilities operated by State and local government would be upgraded as necessary to permit all-weather use. Recreation development costs would amount to about $3.0 million and would support an additional 750,000 recreation days annually. Paragraphs F-26 through F-29 give details of benefit computation. Selected erosion control structures compatible with national river designation are estimated to cost about $1.2 million.

233. Under existing conditions (No Action plan), an estimated 1,000,000 recreation days will occur on public recreation facilities by 1990. Implementation of Plan A is expected to increase the total recreation days to 1,750,000 by 1990. The increment in recreation days will consist primarily of increases in picnicking, boating, fishing, camping, swimming, and hunting.

ENERGY IMPACTS OF PLAN A

234. There are no hydroelectric sites or other energy resource developments existing or proposed on this segment of the Missouri River, so this plan would have no effects on the energy source.

REGIONAL DEVELOPMENT IMPACTS OF PLAN A

235. The primary regional economic impact resulting from adoption of this alternative will be from a significant increase in tourism. Tourists are expected to add $5 million annually to the regional economy. Seasonal and part-time employment would be supported for about 400 persons.

SOCIAL IMPACTS OF PLAN A

236. The quality and variety of outdoor recreation opportunities available within the study area boundaries will be protected and enhanced. Additionally, the cultural, archaeological, and historical resources of the area will be protected and receive some interpretive development and access so that the public can benefit more directly from their presence.

PLAN B - IMPROVED ACCESS WITHOUT DESIGNATION

237. The primary emphasis of this alternative is river access in conjunction with bank stabilization. This is the recommended procedure being pursued in the other Missouri River reaches as described in paragraph D-196.

INCREASED RECREATION DEVELOPMENT OF PLAN B

238. This alternative provides access and service roads, boat launching, and sanitary and other facilities to be developed in cooperation with State and local entities within this segment of the Missouri River.

ENVIRONMENTAL AND LAND USE IMPACTS OF PLAN B

239. This alternative would develop some additional recreational facilities on existing public lands. Further environmental and land use impacts would occur as discussed in the No Action plan.

CONSERVATION AND RECREATION COSTS AND TRENDS OF PLAN B

240. This alternative would provide increased access, boat launching, and sanitary and related recreational facilities. The initial cost of this development is estimated at $346,000, and will accommodate 41,000 initial recreation days with an annual value of nearly $108,000.

ENERGY IMPACTS OF PLAN B

241. There are no hydroelectric sites planned on this segment of the Missouri River, so this plan would have no effects on this energy source.

ECONOMIC AND REGIONAL DEVELOPMENT IMPACTS OF PLAN B

242. Same as No Action plan, paragraph E-226.

SOCIAL IMPACTS OF PLAN B

243. Same as No Action plan, paragraph E-227.

Conclusions

244. It is concluded that:

- The Missouri River main stem from immediately below Gavins Point Dam, 1965 river mile 811.05, downstream to 1965 river mile 752 just above the Champlin pipeline at Ponca State Park be designated a component of the National Wild and Scenic Rivers System as a Recreational River.
- The Secretary of the Army, with the advice and counsel of the Secretary of the Interior and the Governors of Nebraska and South Dakota, should administer the river in accordance with the provisions of the Wild and Scenic Rivers Act.
- The development and management of this component of the National Wild and Scenic Rivers System should give primary emphasis to maintaining and enhancing the historic, esthetic, recreation, fish and wildlife, and geologic values. All recreation facility

development, erosion control, and bank stabilization works be consistent with the protection of those values which enable the river to qualify for inclusion in the National System.

● The delineation of the corridor should be determined by the managing agency in terms of a zone of influence on the natural scene as perceived from the river itself. The senses of sight, smell, and sound all directly relate to the zone of influence. The line of sight is a primary factor which is determined by topography and land use or vegetative cover. Sounds emitting from engines and machinery such as trucks, automobiles, and irrigation pumps are important influences. Offensive odors from land fill, agricultural activity, or poor water quality are important influences as well. These considerations should be factored into the definition of the zone of influence.

● Designated islands and accretion lands should be protected to the extent possible. A detailed survey of these islands should be conducted to determine their recreation and wildlife potential.

● Cultural resources directly and indirectly affected by designation as a National Recreational River should be evaluated and protected as provided by law. Further, they constitute a significant aesthetic component of the river's outstanding value and should, therefore, provide a meaningfull addition to visitor experience. Design and management should provide for responsible and inspirational interpretation of these values.

● Compatible soil and water conservation practice should be encouraged by Federal, State and local agencies; together with enforcement of water quality standards these practices will help to preserve one of the river's outstanding values - an abundance of good quality water.

● Regulation of outflow from Gavins Point Dam in response to multiple-purpose requirements should suffice for recreation activity during more than nine years out of ten.

● The administering agency should determine the recreation use capacity of each segment of the National System and establish a method of visitor control before capacity is reached and implement such controls when necessary. Visitor capacity should relate to maintaining a high quality of recreator experience and the corridor environment and minimizing the impact on private landowners.

● A variety of recreational opportunies should be maintained to the extent practical. Particular activities presently occurring in the corridor which should continue include canoeing, hunting, fishing, nature study, camping, and hiking.

● Local units of government along the river should adopt land use policies and zoning ordinances which are consistent with the purposes of the Wild and Scenic Rivers Act. Zoning objectives should be to prohibit new commercial, industrial, or residential uses which are inconsistent with the purposes of the Act and to protect the shorelands by means of land use restrictions and setback requirements.

● Care should be taken to limit the impact of locating utility corridors within the zone of influence of segments in the National System. Existing utility crossings should be used as much as possible and routes paralleling the river should be avoided so as to have the least disruptive impact on the natural character of the landscape.

Means of Protection

245. Land protection methods should be sufficiently comprehensive to ensure that the natural integrity of the river be preserved for future generations in accordance with descriptive and classification criteria. Property rights acquired within the boundary should be adequate to provide reasonable protection of the natural scene and to accommodate the desired level of recreational use. However, it is the intent of the Wild and Scenic Rivers Act that national wild, scenic, recreational rivers be administered in such a way as to protect and enhance scenic and recreational values without limiting other uses that are compatible and do not substantially interfere with public use and enjoyment of these values.

FEE TITLE ACQUISITION

246. Lands needed to provide access and services to the public and to protect the river and its environment, including unique natural areas which may be jeopardized by less-than fee control, should be acquired in fee title. Fee title acquisition should be limited in order to minimize impacts on the local people and economy.

SCENIC EASEMENTS

247. Necessary protection and control of land use for a major portion of the proposed segments should be accomplished through a combination of the purchase of scenic easements and land use zoning. Essentially, a scenic easement involves acquisition of the right to control certain uses of the land for the purpose of protecting the natural qualities of the river. Easement acquisition may be accomplished through an agreement or series of agreements (for appropriate compensation) whereby a landowner binds himself, his heirs, successors, or assigns to refrain from using or developing the land in ways which would detract from the scenic and natural character of the land. In no instance would scenic easement acquisition restrict, without specific provision, any regular uses exercised prior to the acquisition. The use of an easement in lieu of fee purchase would permit land to remain in private ownership and, therefore, remain on the tax rolls. Maximum standardization of easement conditions is necessary for equability and should include:

- Prohibition of the construction of new structures.
- Restrictions on the allowable extent of the cutting of trees and native vegetation.
- Prohibitions of commercial sand and gravel extraction operations.
- Prohibitions of billboards and advertising signs.
- Prohibitions of piles of trash or other unsightly materials.
- Restriction of the land to specific existing developments, such as single family residential and recreation uses. The natural

character of sand dunes, wetlands, native vegetation, and the existing patterns of cultivation, grazing and timber growing will be preserved by specific arrangement.

- Restrictions of livestock grazing and watering in the river but only after such grazing and/or watering have been determined to be environmentally detrimental or inconsistent with the public use of the river by the administering agency.

- Any necessary requirements for screening or otherwise modifying present or future water intakes or other riverside installation.

248. The location and depth of these easements would depend on the topographic and land cover circumstances of the corridor. A scenic easement, for instance, might be acquired on a property one-half mile away from the main channel in order to preserve a fringe of trees bordering a marsh that the river channel meanders through. In another case where the river traverses a high bluff, a sufficient easement could consist of a narrow strip only 100 feet deep or less along the high bank.

RECREATION EASEMENT

249. A recreation easement is similar to the scenic easement with one major exception. The recreation easement would allow public use of the private lands, while possibly specifying the uses that could occur, i.e., hiking, boat beaching, picnicking.

ZONING

250. If local units of government along the river should adopt and enforce land use policies and zoning standards which are consistent with the purposes of the Wild and Scenic Rivers Act, as advocated in paragraph E-244, the need for scenic easement acquisition would be eliminated in most, and perhaps all areas.

Management

The management goal for this segment of the Missouri River should be to protect and enhance the values reflecting the rationale for its inclusion in the National Wild and Scenic Rivers System. Management objectives should be to:

- Maintain the river's natural, free-flowing condition.
- Protect and enhance scenic, recreational, geologic, fish and wildlife, historic, archaeologic, and other similar resources.
- Maintain or enhance water quality.
- Provide opportunities for river-oriented recreation which are consistent with protection of the quality of the river and its environment.

Evaluated Accomplishments

252. Designation of this reach as a component of the National Wild and Scenic Rivers System will provide permanent protection and enhancement of the recreational, geologic, fish and wildlife, historic, archaeologic, and other values on this 59.05-mile segment of the Missouri River. These values will be retained for both recreation and scientific benefits for generations to come through selective land acquisition, easements, intensive management, and environmentally sensitive placement of compatible erosion control and bank stabilization structures.

253. Estimates indicate that ultimate demand will be 750,000 additional recreation days within the designated segment of the Missouri River. Increase opportunity will be provided through improved access, recreational development, and resource preservation. Regional tourism is expected to increase markedly, with above 90 percent of the additional visitation anticipated from beyond bordering counties. Assuming that each visitor from outside the bordering counties will spend $7.50 per day, $5 million annually will be added to the regional economy. Other identifiable social effects include additions to traffic volume amounting to about 200,000 "vehicle days" per year and 677,500 average annual visitors. Of the $5 million expenditure, approximately $170,000 would be for gasoline tax and

$170,000 for sales taxes. Seasonal and part-time employment would be supported for about 400 persons.

Effect on the Environment

254. The selected plan (Plan A) will provide for perpetuation of the existing setting within the river's high banks and within view from the river surface perspective. Preservation of this outstandingly remarkable resource will, however, require structural erosion control measures. Without such measures, destruction of the river's settings and some values will ultimately occur. The structural measures that will be used will only be those that are considered environmentally and structurally compatible with National Wild and Scenic River designation. A calculated trade-off between using proposed structural methods to preserve both the instream and bank line features versus no controls, and losing some of these features altogether, forms the basis for selecting Plan A.

255. The overall environmental effect of the selected plan will be beneficial in terms of aesthetics and overall natural resources preservation. The development included in the selected plan for this segment of river will provide for maximum use without significant degradation to the environmental setting or the natural resources.

256. Biological effects will consist of preservation of the existing resources and systems within the river's high banks to the greatest extent feasible while retaining its dynamic character. The islands, backwaters, wetlands, side-channels and sand bar-cluster-reaches to be preserved are considered beneficial habitat types for the river's population of fish, birds, reptiles, amphibians, and mammals. Conscious retention of an adequate supply of these areas is one of the objectives of the plan. Without the scenic easement aspect of the plan, much existing high bank bottomland forest would ultimately be eliminated in favor of plow agriculture.

257. Preservation of low and high bank woody habitat will be of particular benefit for white tail deer. The preserved clusters of sand bars furnish nesting for the Interior Least Tern, and contribute significantly to the usefulness of the river reach as a major spring and fall staging area for migratory waterfowl. The river in its present condition probably serves as spawning grounds for the paddlefish that occupy the Missouri River below Gavins Point Dam, even though reproduction of paddlefish in this reach has not been verified.

258. Physiographic effects of the plan are summarized as follows:

- Long-term preservation of features identified as outstanding or unique and which would otherwise ultimately be destroyed or significantly changed.

- Some structural means are required to effect the above preservation. Placement of high bank erosion control structures and in-channel structures, compatible with National Recreational River designation, will constitute a physiographic impact, in itself.

- Some changes will occur through provision of added and improved public access and activity areas necessary to accommodate increased public use.

- Removal of automobile bodies, rubble, and other homemade erosion control structures and replacement where necessary with bank protection structures described earlier in the report will change the overall appearance of the bank areas.

- The appearance and noise levels of irrigation pumps and other private structures in the river under permit will be designed and screened so as to reduce significant adverse aesthetic effects on the public values of the river.

259. Effects of the plan on cultural and historical resources will be beneficial. The corridor directly affected by Federal action will be surveyed, and any sites identified will be preserved. Cultural and historical resources will thus be identified and their values

protected by the plan.

260. Historical and cultural resources known to exist but not precisely located or existing outside of the corridor to be directly affected will, in many cases, have a degree of interpretive value and contribute to the uniqueness of the river, though they may not be directly affected by the plan.

Other Effects

261. The purpose of the Wild and Scenic Rivers Act of 1968, as amended, and the objective of this plan, is to contribute to the long-term quality of life in the Nation. The effects will be most marked at and near the designated rivers, and become less specifically identifiable in proportion to distance from the river. This observation applies to any National Park, National Forest, or other major Federal installation or designated area. The cumulative social and economic effect of all such areas is identifiably national.

262. The selected plan (Plan A) will perpetuate recognized outstanding natural and recreational values along a representative natural segment of one of the Nation's major waterways. National and regional recreation opportunity will be appreciably enhanced. The significance of this enhancement will increase through time as the Nation's open space and wildlife habitat resources are reduced. The presence of this enhancement will increase overall attractiveness of the region as a place to live. This should improve the potential for industrial growth in regional population centers. Thus, a concomitant regional economic benefit is anticipated, but is not considered quantifiable.

263. Reasonably foreseeable potential uses of land and water which will be foreclosed or curtailed are those intentionally limited by the project design. These include the options to clear existing forested areas important to the recreation river concept, to

indiscriminately develop cottage sites on other potentially unsightly real estate improvements, or to radically alter existing land use patterns.

264. Discretionary powers concerning land use and development now exercised by individual landowners will be curtailed - in some cases involuntarily. This amounts to some loss of individual liberty and is thus considered as an adverse effect, even though due process is carried out. The intention of the selected plan is to effect an optimum compromise between public and private interests over the long term. Specifically, real estate interest needs are minimized.

Design

265. The selected plan consists of Federal acquisition of land, construction of recreational facilities, and river access and construction of selected structures compatible with National Wild and Scenic River designation. Plates E-46 through E-54 present the plan's design.

LAND ACQUISITION

266. Lands to be acquired are to accommodate recreation facility development, public use, and the preservation of the river and high bank features which make the river eligible for designation. Estimated land requirements include 424 acres in fee simple; 1,705 acres in scenic easement; and 12,812 acres in recreation easement which includes up to 6,648 acres of submerged riverbed. River access facilities will be improved at the existing public access points on the river, except at the Downstream Recreation Area of the Gavins Point project where access facilities are adequate. Recreation facilities will be developed at six additional areas to be acquired - two of which are islands.

267. Acquisition of lands in fee simple is proposed for specific areas that will support recreation facilities and public overnight use that require safeguards against fires, landscaping to accommodate

tents and other camping units, and camper safety.

River Mile Location	Estimated Acres
753 Left Bank	200
763 Right Bank	15
776 Right Bank	57
785 Island	40
787 Right Bank	60
800 Island	40
Access roads (general)	12
	424

268. River mile 753L site (South Dakota Downstream Area) will receive the greatest amount of development. A camping area of approximately 100 camp pads, potable water supply, and waterborne sanitary facilities, together with a picnic area and river access, will be provided. Primitive camping will be provided for at the Nebraska bluff sites at river mile location 763R, 776R, and 787R. In addition to campfire rings and adjoining tent area clearing and landscaping, vault or pit toilets and a boat beaching area will be developed. On the bluff sites that will be accessible by automobile, all weather parking lots will be added. A boat beaching area, vault or pit toilets, campfire rings and adjoining tent area clearing and landscaping will be provided on the two major islands. These areas will be fenced as necessary to exclude livestock.

269. Recreation easements totaling 36.8 miles in length will be sought between the high banks of the river in the following reaches:

River mile 753.6 - 764.0
River mile 765.3 - 781.0
River mile 782.5 - 788.0
River mile 792.8 - 795.0
River mile 798.0 - 801.0

270. All of the sand bars and low bank lands in these reaches would be available for public day-use. Recreation easements, in addition to providing physical use of the land by the public compatible with Federal and State law, will restrict the owner from making significant land use changes of a nature that would adversely affect public use, wildlife use, and the land's aesthetic values. Timbered areas would remain in timber with clearing limited to silviculture practices designed to perpetuate the natural forest conditions. Owners would also be restricted from placing items on recreation easement lands that would jeopardize public safety or reduce the values and space important to public recreation. Controlled burning, consistent with state and local law would be permitted if not inconsistent with other limitations placed on the land. Recreation easement conditions would be specific to each tract of land acquired to accomplish the long-term public interest within the wild and scenic river concept and permit the widest scope of continued private use of the land.

271. Scenic easements will be acquired where local zoning ordinances are not adequate to protect the long-term environmental and aesthetic quality of the river's high bank land and shoreline as viewed from the river. Scenic easements will be acquired generally along both banks the full length of the designated reach from Gavins Point Dam to Ponca State Park. Some reaches will be narrow and some much wider, particularly at reaches where gradual slopes or steep bluff lands make up an important visual feature of the designated river. The fundamental purpose of the scenic easement is to retain the river shoreline appearance in a condition that is compatible with Recreational River classification.

272. Private owners will not be permitted to place additional habitable structures, permanent or temporary, on easement land. Permits issued for construction of boat ramps, docks, and water intakes for agricultural purposes must be responsive to and compatible

with National Recreational River designation.

273. Industrial pipeline crossings may be accommodated, but with special restrictions that would protect both the river water quality from pollution due to accidental spill and the aesthetics of the area. These and similar restrictions will be expressed in the terms of the easements and Federal permits issued in accordance with Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of PL 92-500. Scenic easements will permit retention of existing structures and other items that are out of conformance with the terms of the easement, but the exclusion will be limited to the owner of record at the time of easement-taking and cannot be conveyed, repaired, or restored, and structures must be removed upon termination of useful life.

REHABILITATION

274. The vast majority of car bodies and rubble placed along the river banks were installed in violation of Section 10 of the Rivers and Harbors Act of 1899 or of Section 404 of the Federal Water Pollution Control Act. These are private attempts to control high bank erosion. It is presumed that formal bank erosion control structures will replace most of these, and that few of the car bodies will remain in place. Those that do will be dealt with on a case by case basis as required by law.

Construction

275. Implementation of the selected plan may take five to ten years. Real estate acquisitions and construction are to be Federal responsibilities, as indicated in Table E-20, at the end of this section.

Operation and Maintenance

276. The Nebraska-South Dakota boundary is indeterminate between the Missouri River high banks within the National Recreational River reach. Some problems in law enforcement could arise because of the lack of a well-defined state boundary in this area and the attendant

uncertainty of the jurisdictional authority of each state's law enforcement personnel. The States' authority to budget and expend funds for the operation and maintenance of the designated river and associated recreation facilities would, however, be limited to intra-state programs. Because of this restriction and the indeterminate States' boundary, it would be inappropriate to promote one State or the other to unilaterally operate and maintain the designated recreational river. Federal operation and maintenance of lands and facilities of the recreational river, particularly within the river's high banks will eliminate the State boundary problem. No Federal agency that is in the business of outdoor recreation operations and maintenance except the Corps of Engineers has established administration and maintenance facilities in the vicinity of the National Recreational River reach. The development of another, essentially duplicative, Federal opening office and staff would not be cost effective. The Corps of Engineers, therefore, will be the Federal Government's managing agency. The State of Nebraska and South Dakota, affected city and county government agencies, and the Bureau of Outdoor Recreation will be consultating agencies.

EXISTING FACILITIES

277. At several existing facilities now serving the study reach a continuation of present operation, maintenance and replacement activities will be continued by:

The State of South Dakota: will continue to operate and maintain Clay County State Recreation Area and the three game production areas that border the river and that provide public use facilities and space in support of public visitation.

The State of Nebraska will continue to operate and maintain Ponca State Park.

Cedar County, Nebraska, will continue to maintain its river access area.

The City of Yankton, South Dakota, will continue to operate, maintain and replace facilities in its riverside city park.

278. With the exception of those situated in the Yankton City Park, the facilities identified in the previous paragraph do not conform fully to standards appropriate for a National River segment. Improvements in river access (such as boat ramps, boat docks, vehicle parking space, interior roads and minimum sanitation facilities) will be constructed with Federal funds at the several sites, after which the additional operation, maintenance and necessary replacement will be assumed by the present non-Federal site manager.

279. South Dakota will provide land management, operation, maintenance and replacement as needed at the new facilities to be constructed by the Federal Government at the South Dakota Downstream Area — the lower terminal public use area on the left bank -- in accordance with a recreation lease to be administered by the Corps of Engineers after that agency has acquired the necessary land. The Nebraska downstream terminal will be at the existing Ponca State Park. Nebraska will enter into arrangements with the Corps, similar to those of South Dakota, covering three right bank sites at the Nebraska Bluffs.

280. The Corps of Engineers will perform all necessary real estate compliance inspection of lands and interests Federally acquired for scenic and recreation purposes. One semi-annual inspection will take place during the recreation season to assure availability of public access. The second will occur during the off-peak season to prevent undetected conduct of prohibited activities such as timber felling.

281. The Corps of Engineers, Gavins Point Dam operation and maintenance forces and Park Manager's, staff will continue to administer that projects downstream public use areas. These areas will provide the upstream terminal area for the national river. This Corps of Engineers project office will also provide for the operation and maintenance, and replacement of facilities as necessary at the public

use development of both island areas. It is anticipated that routine maintenance during the summer season will have to be provided about three times a week, dropping to once a week during the spring and fall and virtually none during the winter. There will, however, be a need to spend time during the early spring opening the sanitary facilities, placing the boat docks in the water, clearing debris from the boating beaches and repairing ice damage. A period of time will also be required for closing these same facilities at season's end. The maintenance of stabilization structures and the preservation of river values will also be a Federal responsibility.

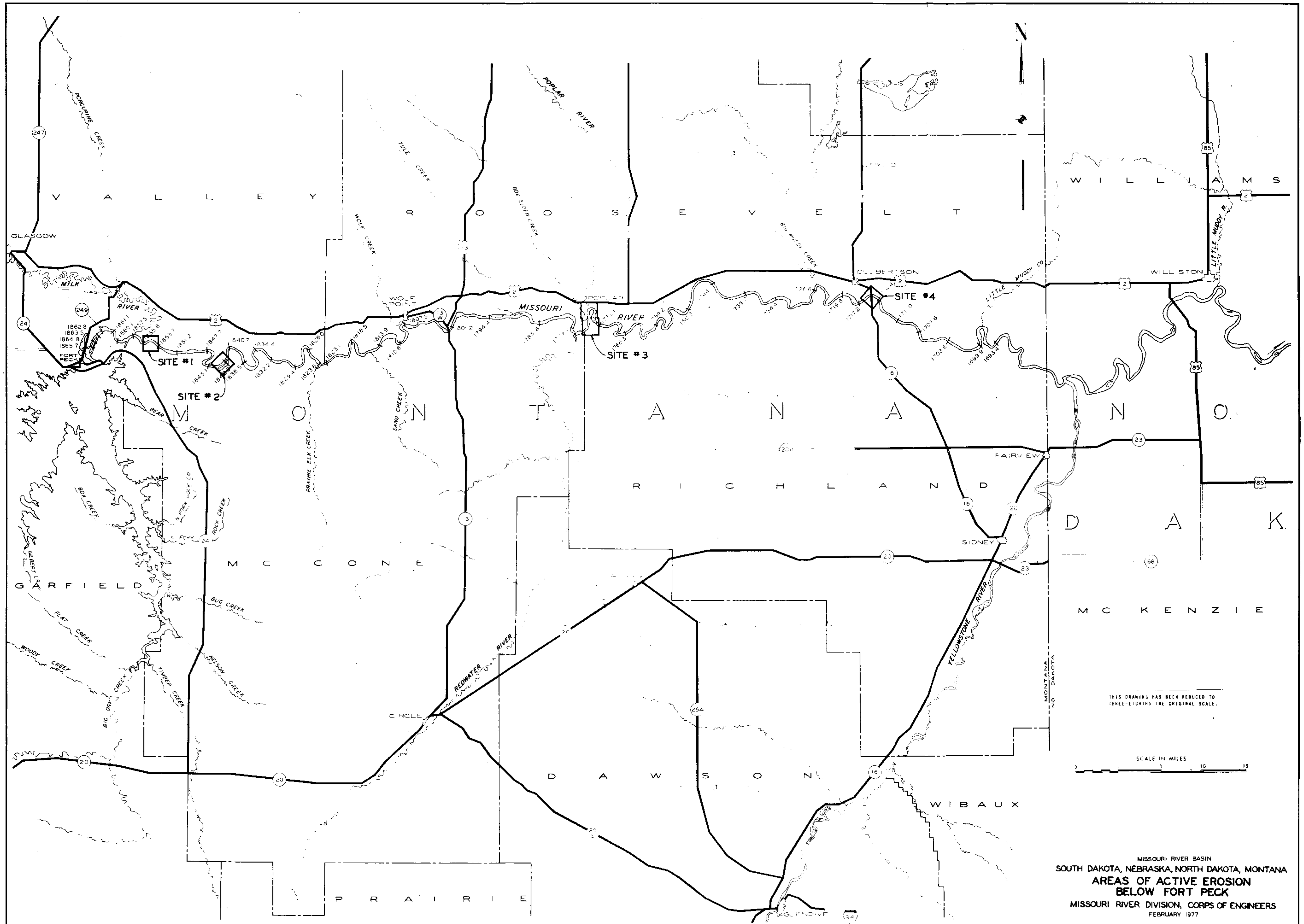
282. Management headquarters of the National Recreational River will be the Gavins Point Dam visitors center. That project's park manager and staff will provide the overall management of the recreational river, coordinating the necessary public information program, opening dates, closing dates, and the like with Nebraska, South Dakota, the bordering counties and the Bureau of Outdoor Recreation. The existing yearly Lewis and Clark Lake Interagency Council meetings will be expanded to obtain Federal and non-Federal agency input for the routine operation and maintenance program of the national river.

283. Table E-20 identifies the responsibility for initial construction or acquisition of an interest in lands, and for operation, maintenance, and replacement of the wild and scenic river elements. The estimated annual cost of Federal operation, maintenance and replacement is $104,200; the corresponding non-Federal cost is estimated at $61,600. Federal annual interest and amortization amount to $495,000 per year.

Table E-20 RESPONSIBILITY FOR DEVELOPMENT AND MAINTENANCE COSTS

Project Feature	Development Cost	O&M Cost	Replacement Cost
Land for preservation of river high bank features (scenic easement)	Federal	Federal	--
Land for public use and development			
Nebraska Bluffs (fee land)	Federal	Non-Fed 1/	--
SD Downstream Area	Federal	Non-Fed 1/	--
Island Areas	Federal	Federal	--
Recreation Easement	Federal	Federal	--
Within bank structures for preservation	Federal	Federal	--
Facilities development at existing public use areas	Federal	Non-Fed	Non-Fed
Facilities development at new sites			
Nebraska Bluffs	Federal	Non-Fed 1/	Non-Fed 1/
SD Downstream Area	Federal	Non-Fed 1/	Non-Fed 1/
Island Areas	Federal	Federal	Federal

1/ Recreation lease requirement



MISSOURI RIVER BASIN
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
AREAS OF ACTIVE EROSION BELOW FORT PECK
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

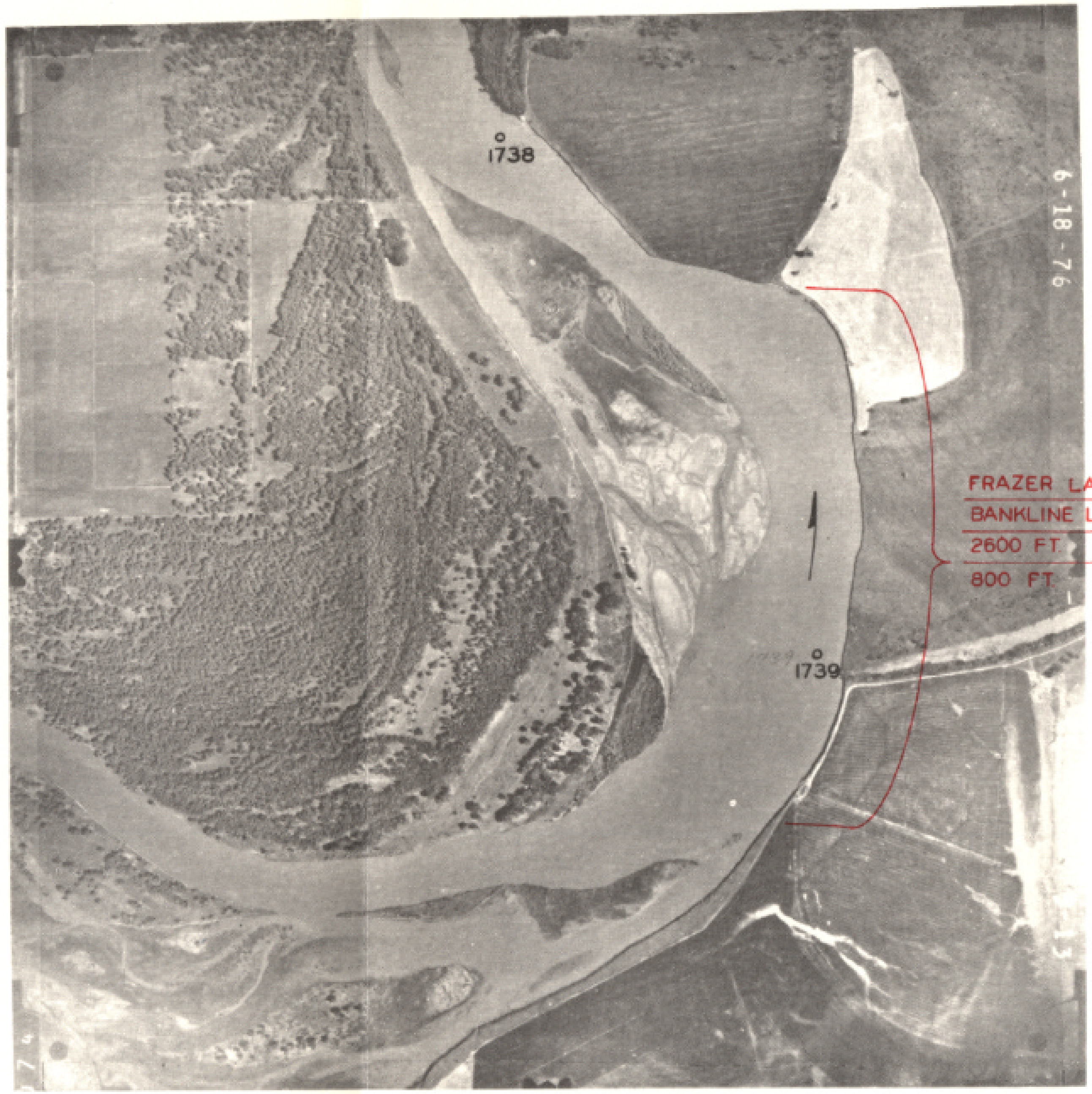
APPENDIX I
PLATE E-1

N

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT PECK DAM TO LAKE SAKAKAWEA
PLAN OF BANK PROTECTION
RIVER MILE 1758 TO 1759
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

N



FRAZER LAKE

BANKLINE LENGTH	STRUCTURE TYPE
2600 FT	COMPOSITE REVETMENT
800 FT	VANE DIKE

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT PECK DAM TO LAKE SAKAKAWEA

PLAN OF BANK PROTECTION
RIVER MILE 1738 TO 1739
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

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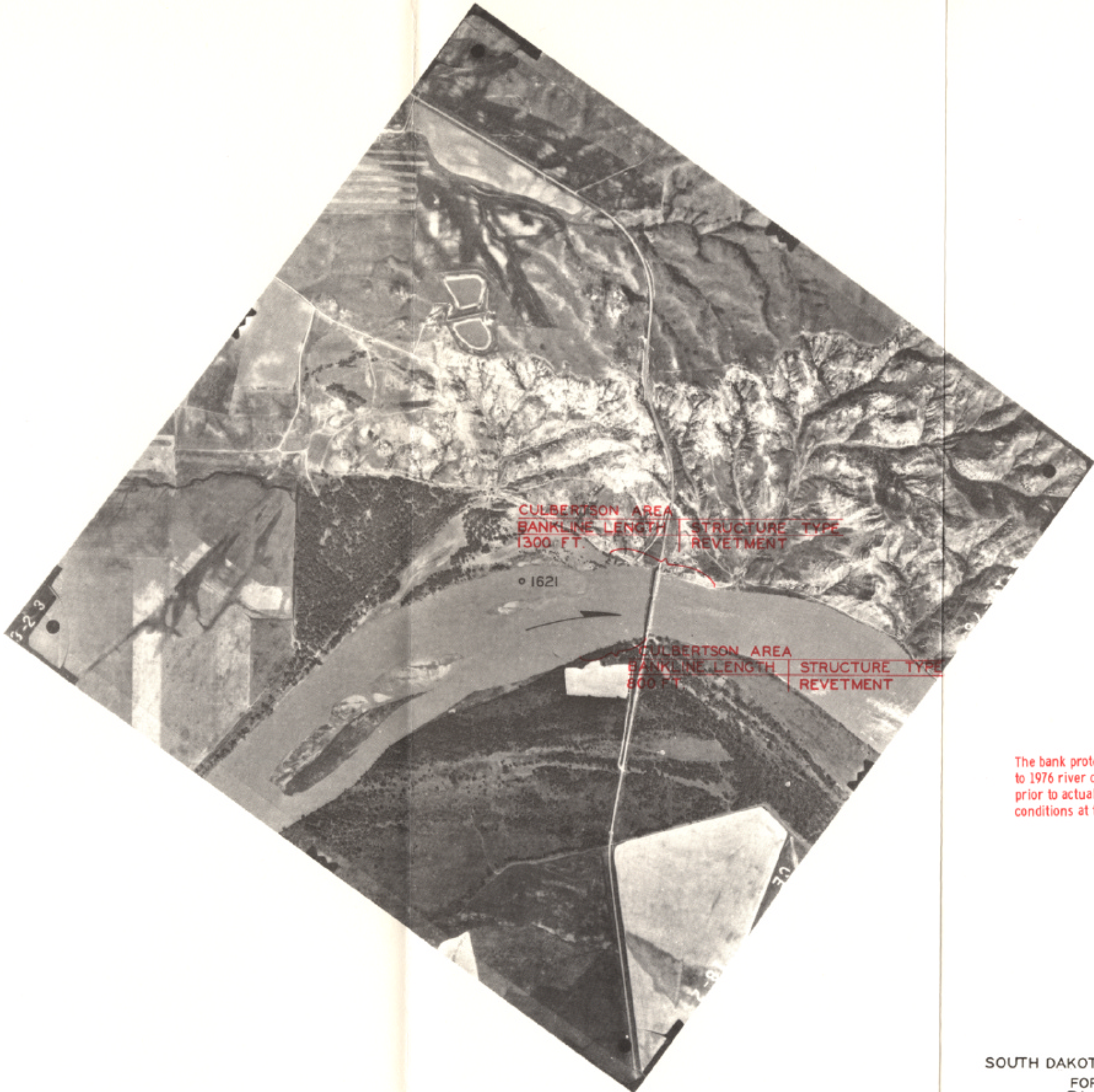
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT PECK DAM TO LAKE SAKAKAWEA
PLAN OF BANK PROTECTION
RIVER MILE 1676 TO 1679
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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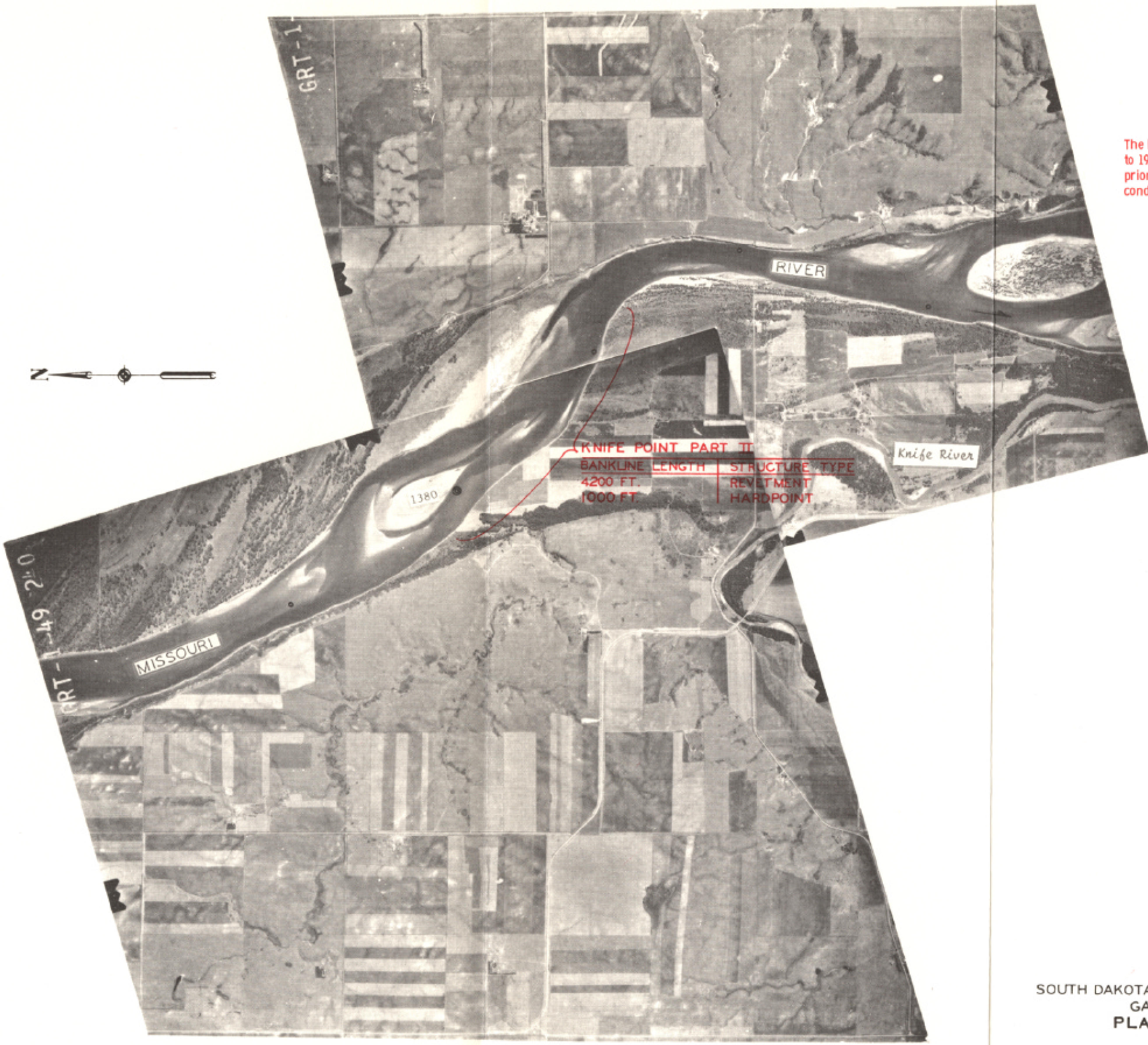
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT PECK DAM TO LAKE SAKAKAWEA
PLAN OF BANK PROTECTION
RIVER MILE 1621
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1382 TO 1389
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-6



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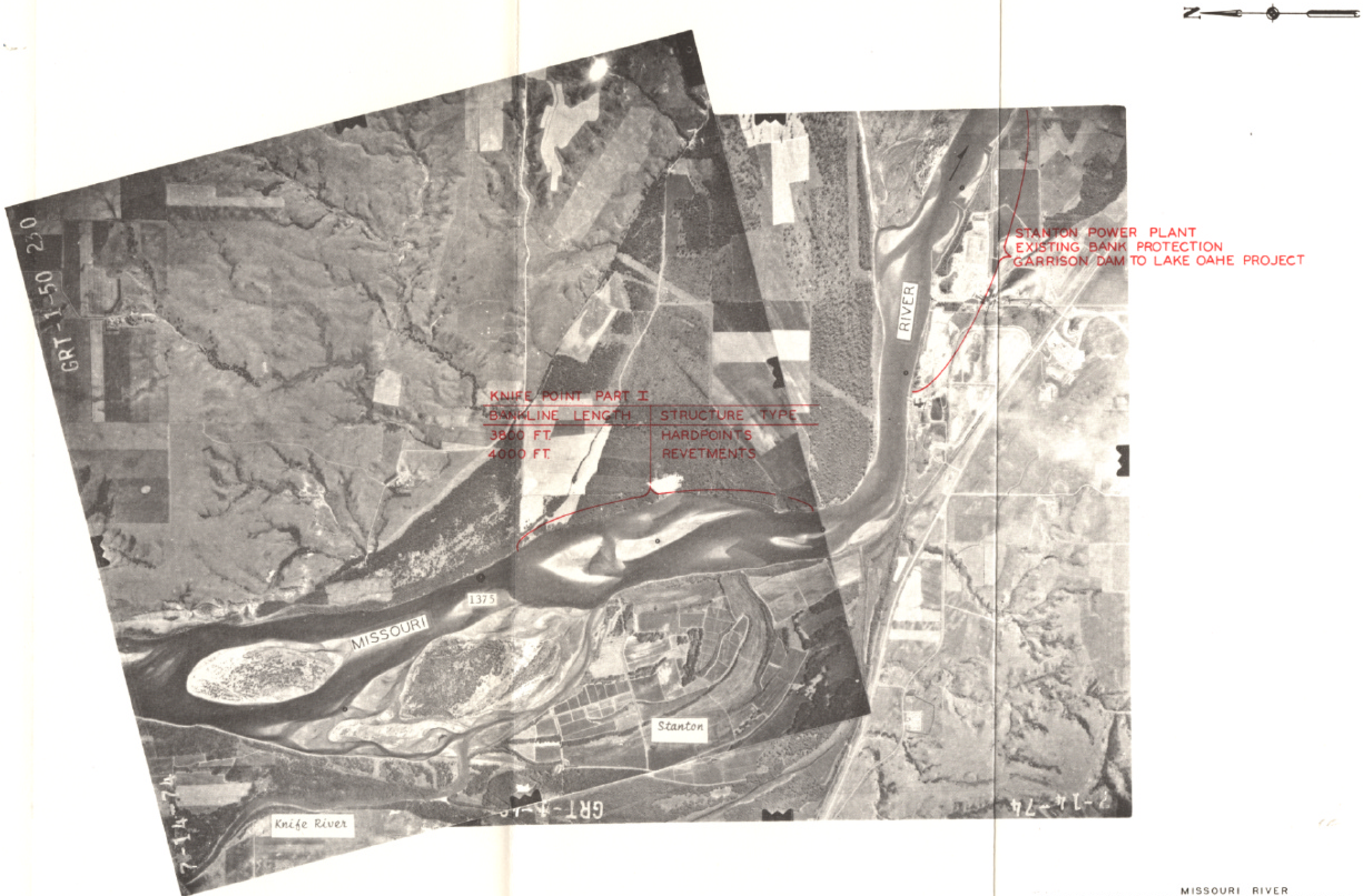
SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1377 TO 1381
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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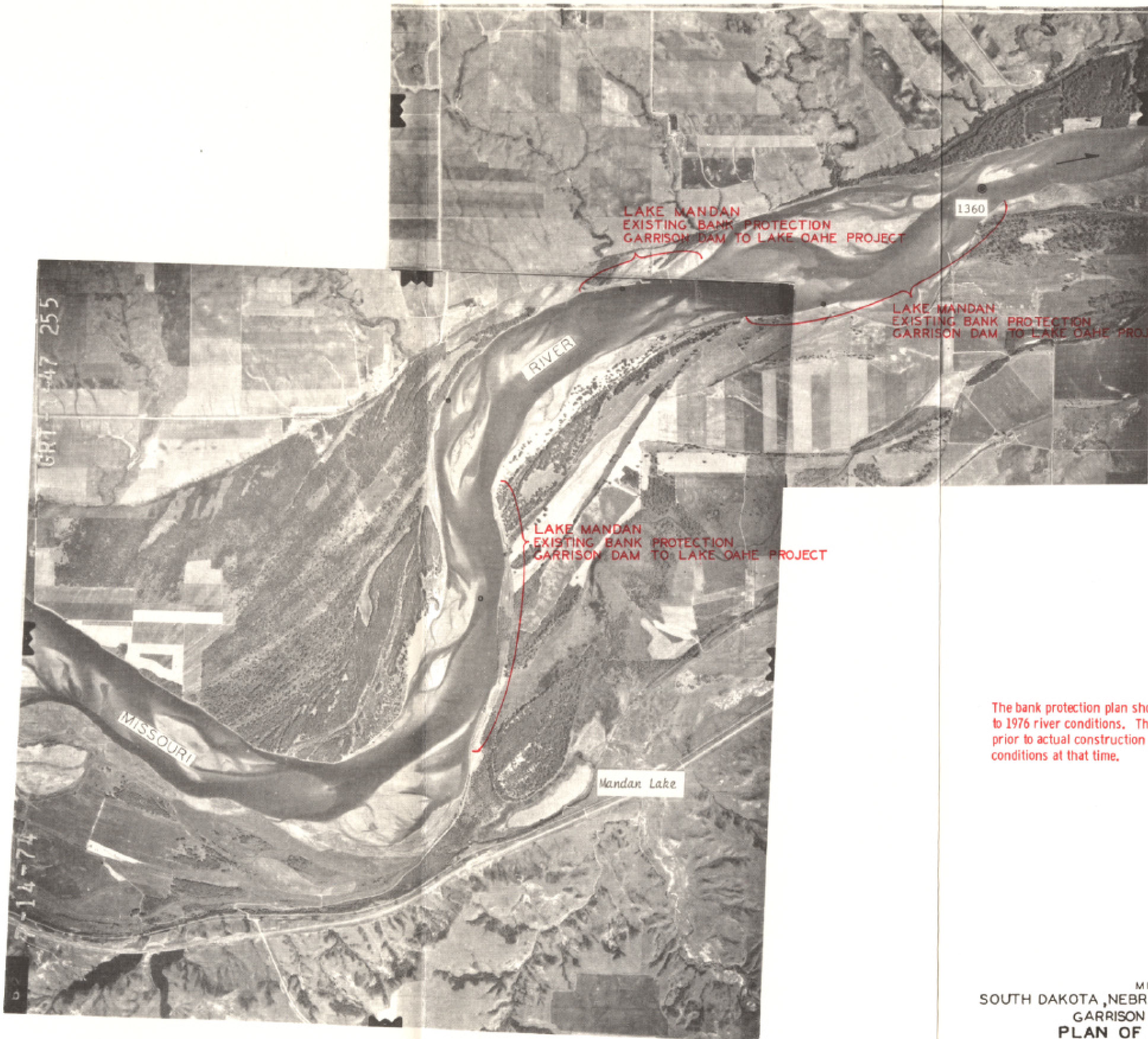
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1371 TO 1376
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

N

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1365 TO 1370
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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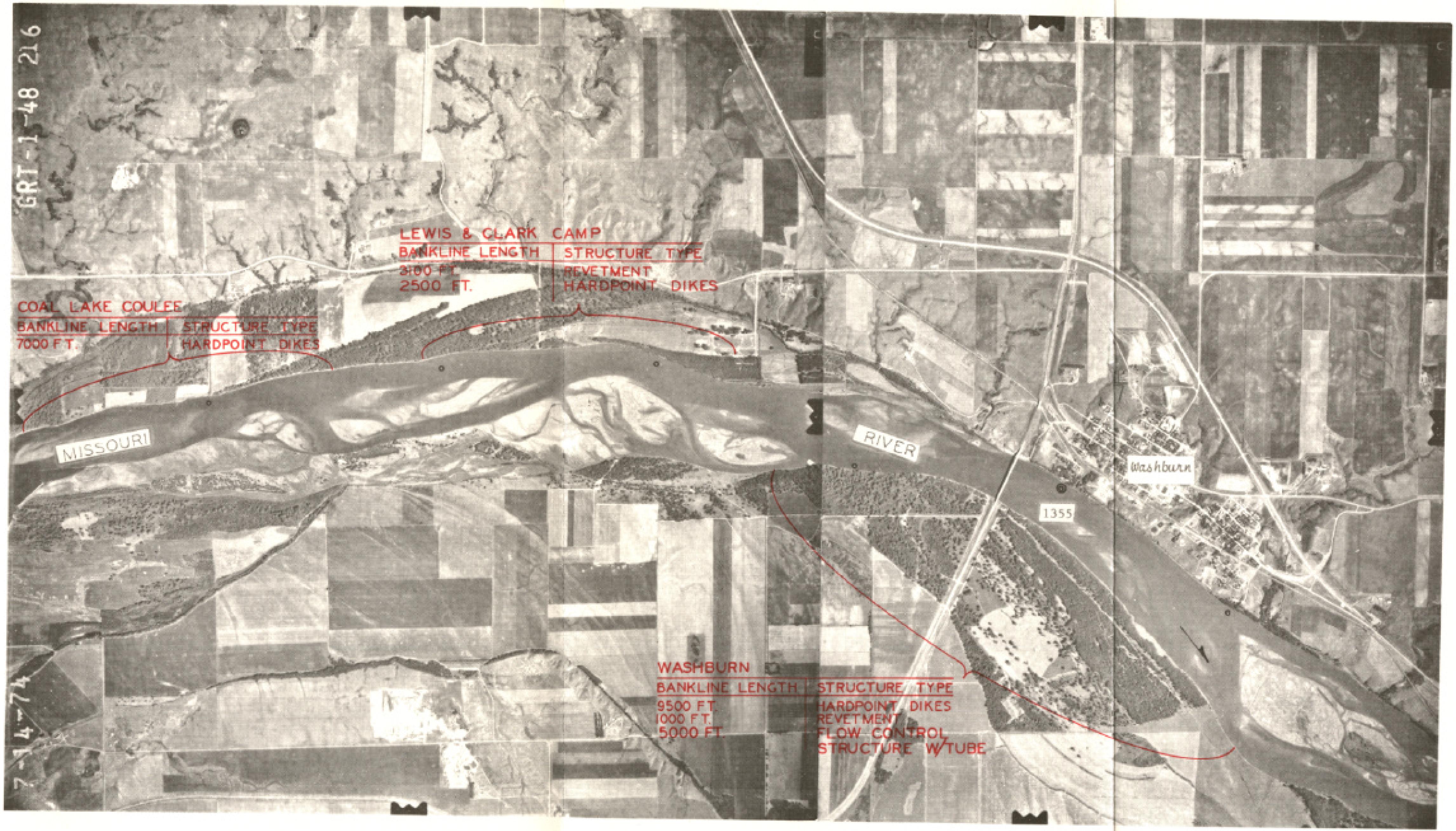
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1360 TO 1364
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1354 TO 1359
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1347 TO 1353
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

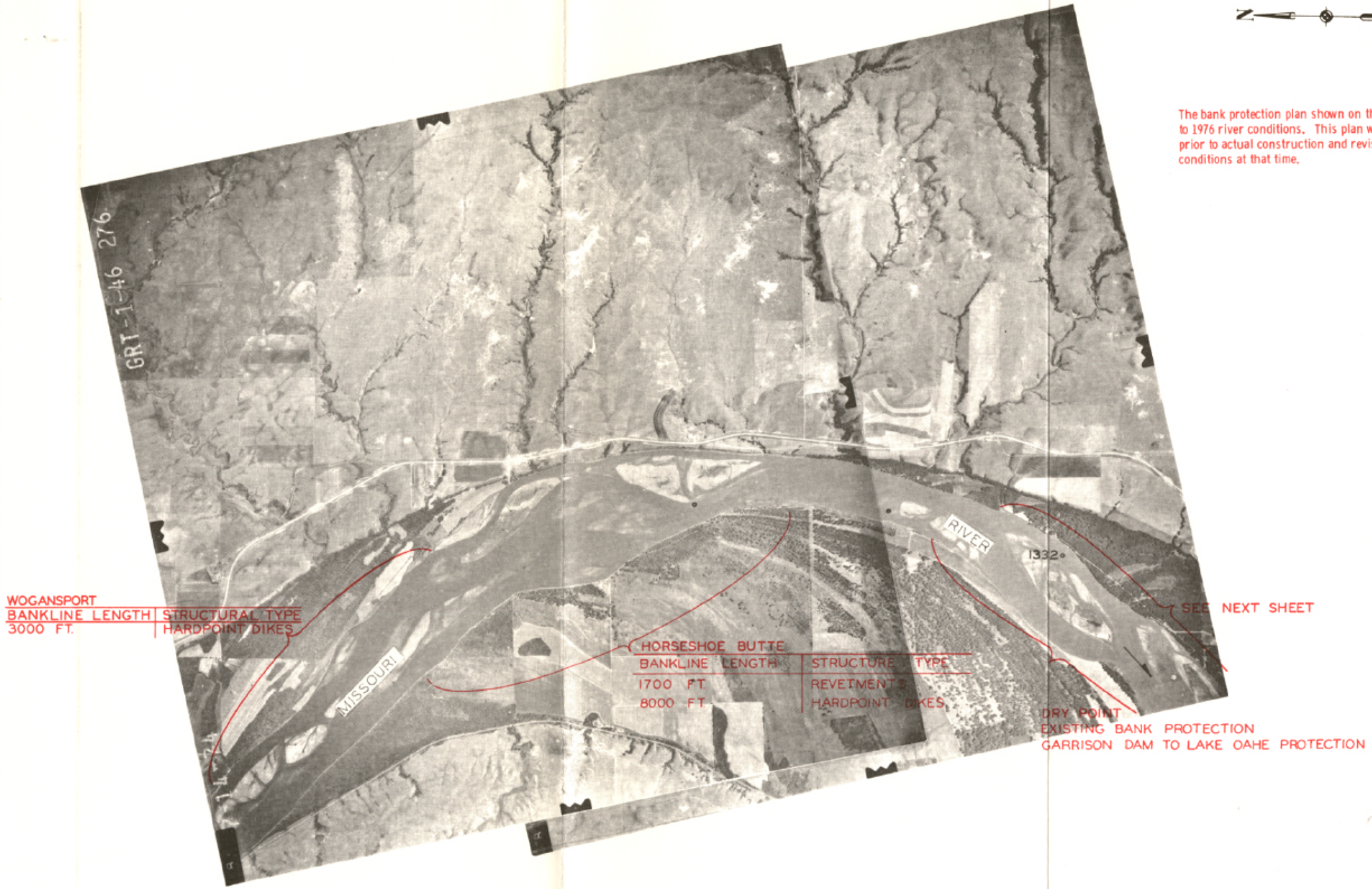
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1341 TO 1346
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-13

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1335 TO 1340
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

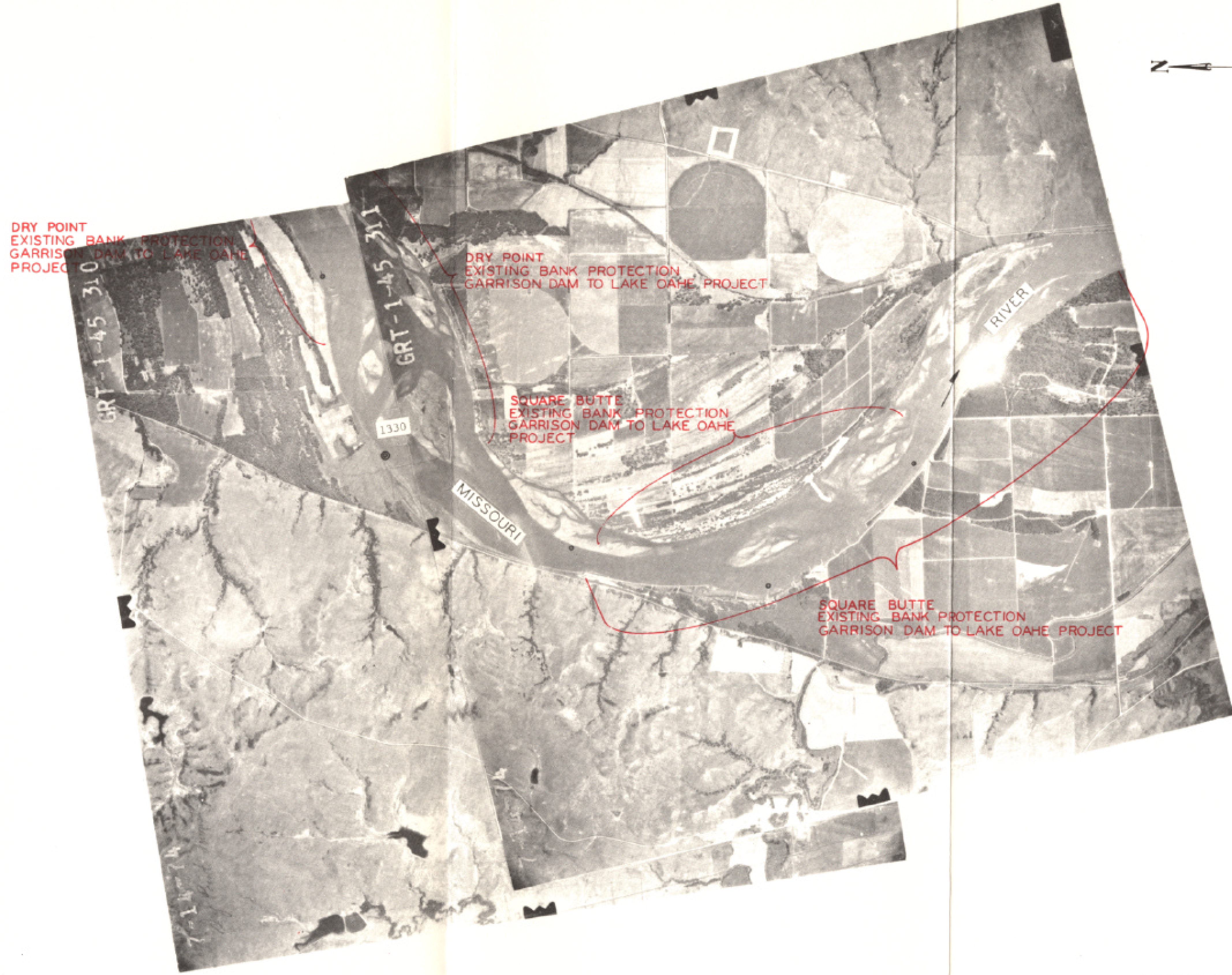
The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE

PLAN OF BANK PROTECTION

RIVER MILE 1332 TO 1334
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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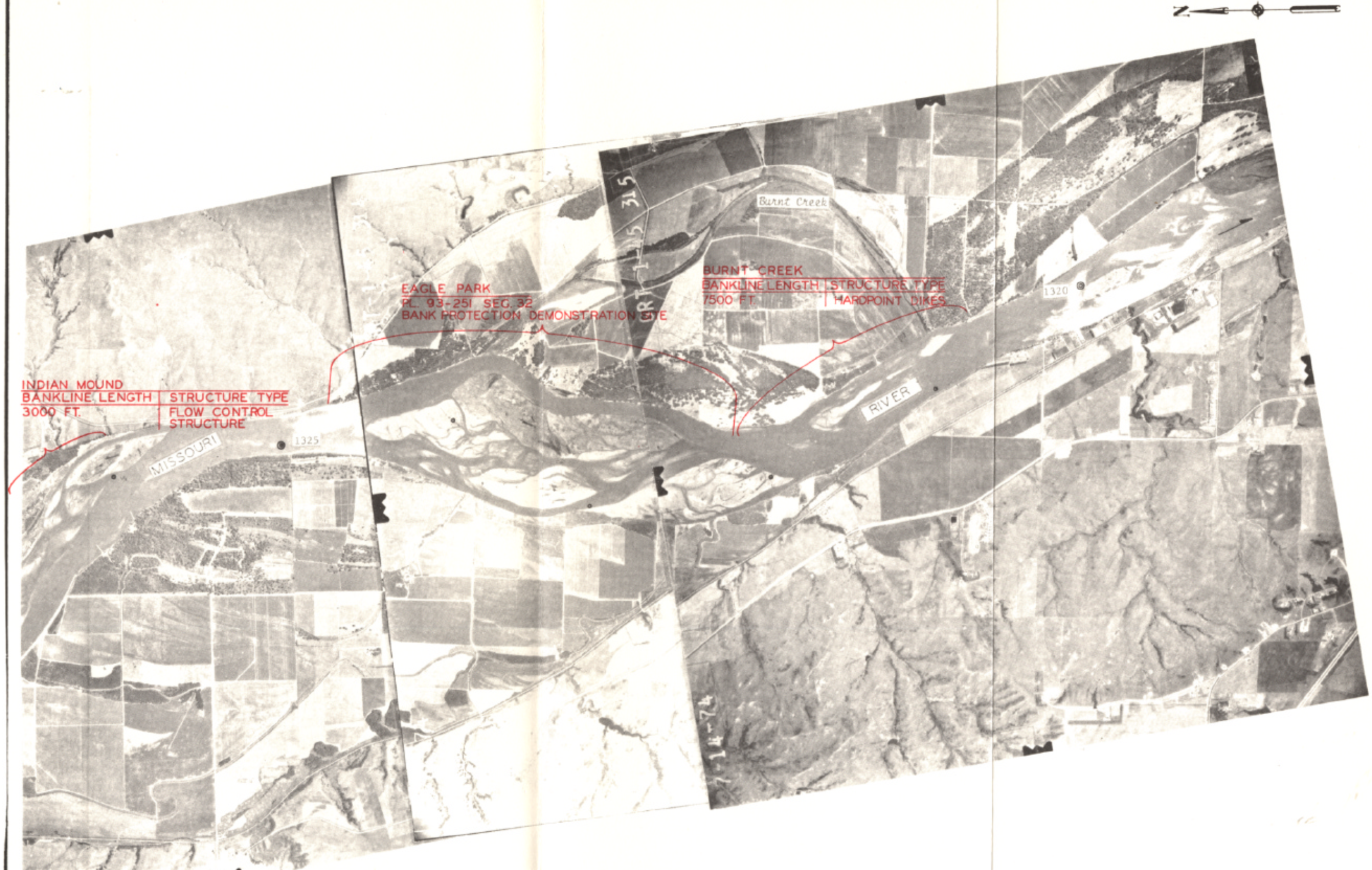
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1327 TO 1331
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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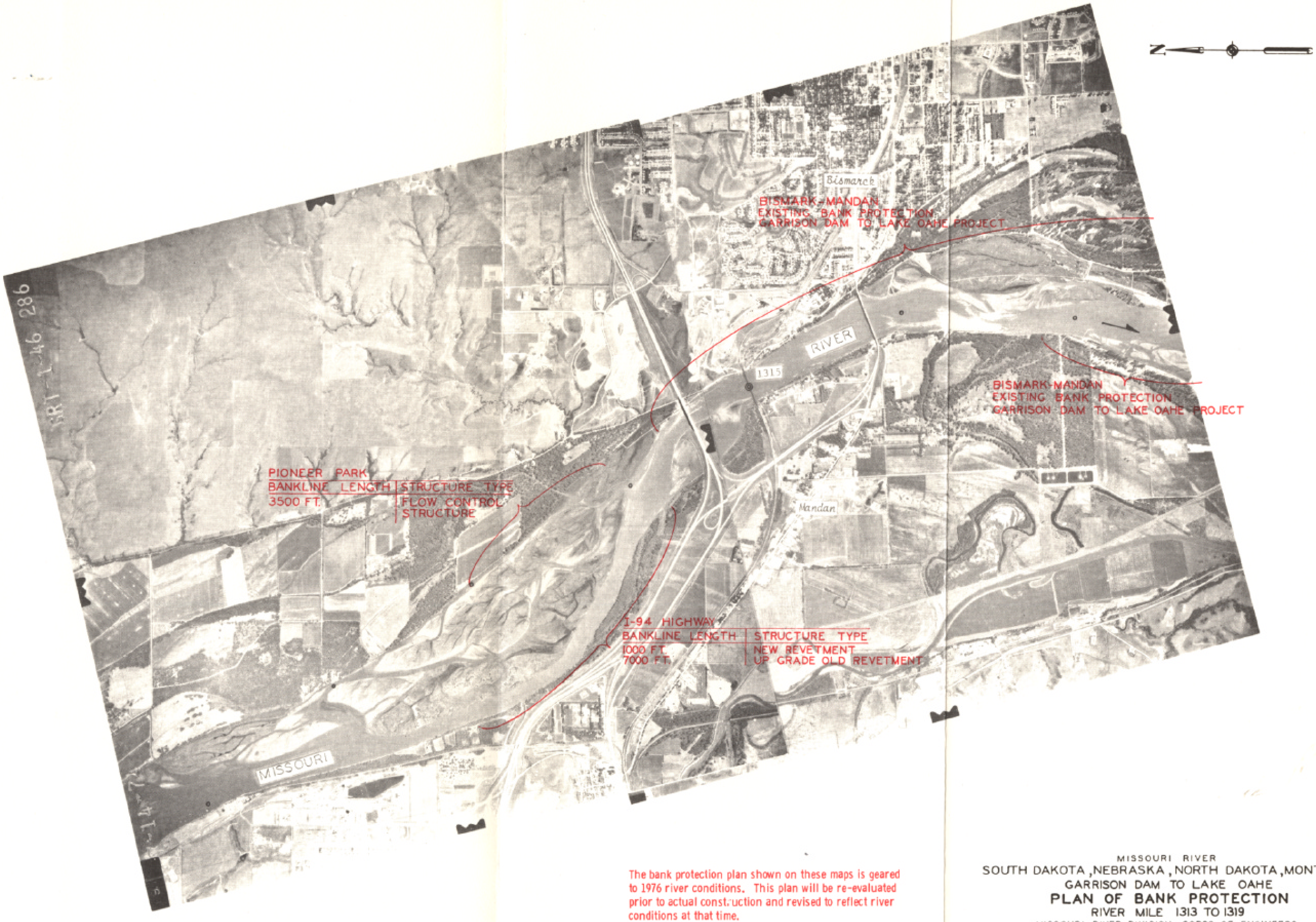
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1320 TO 1326
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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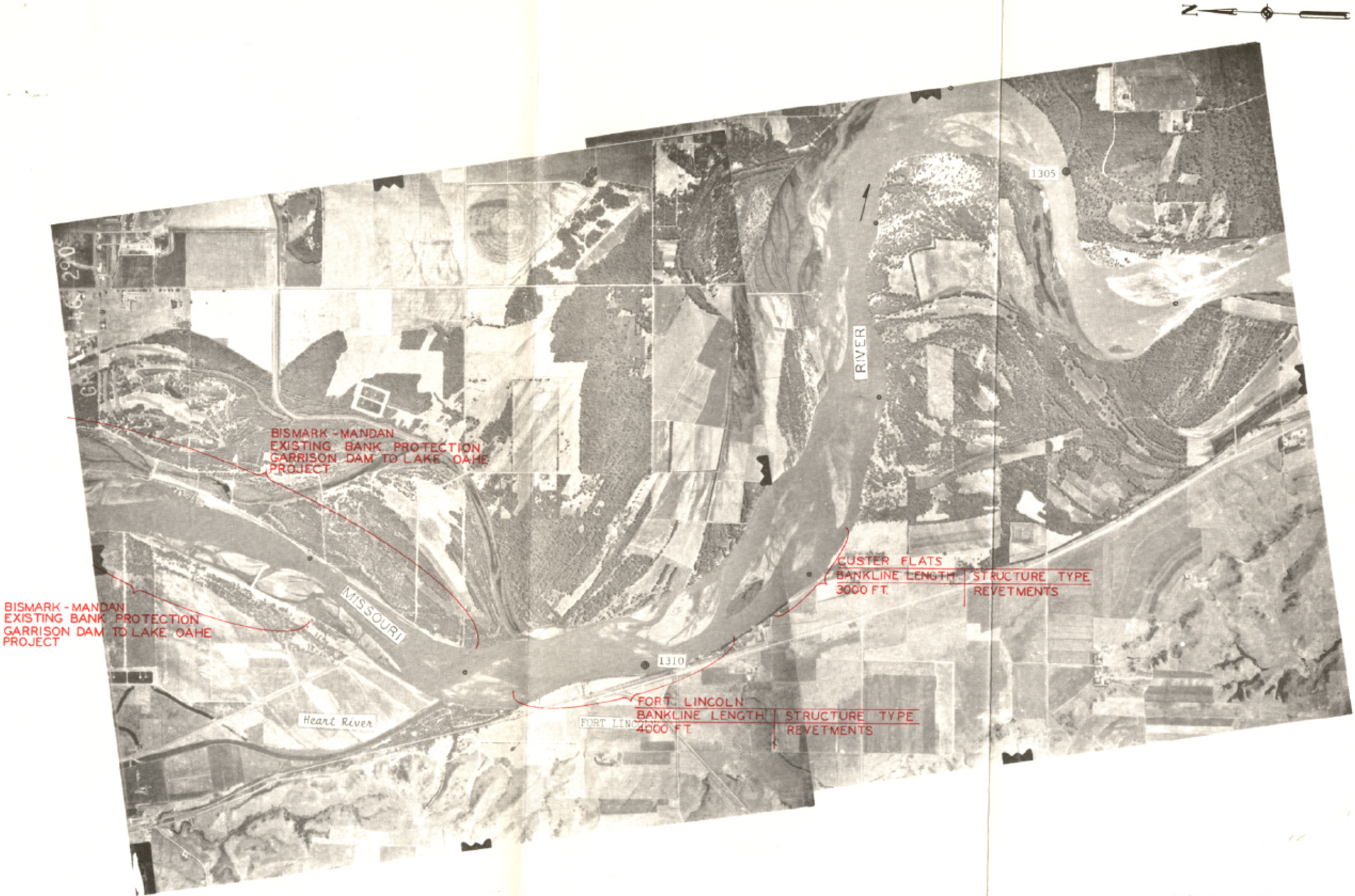
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1313 TO 1319
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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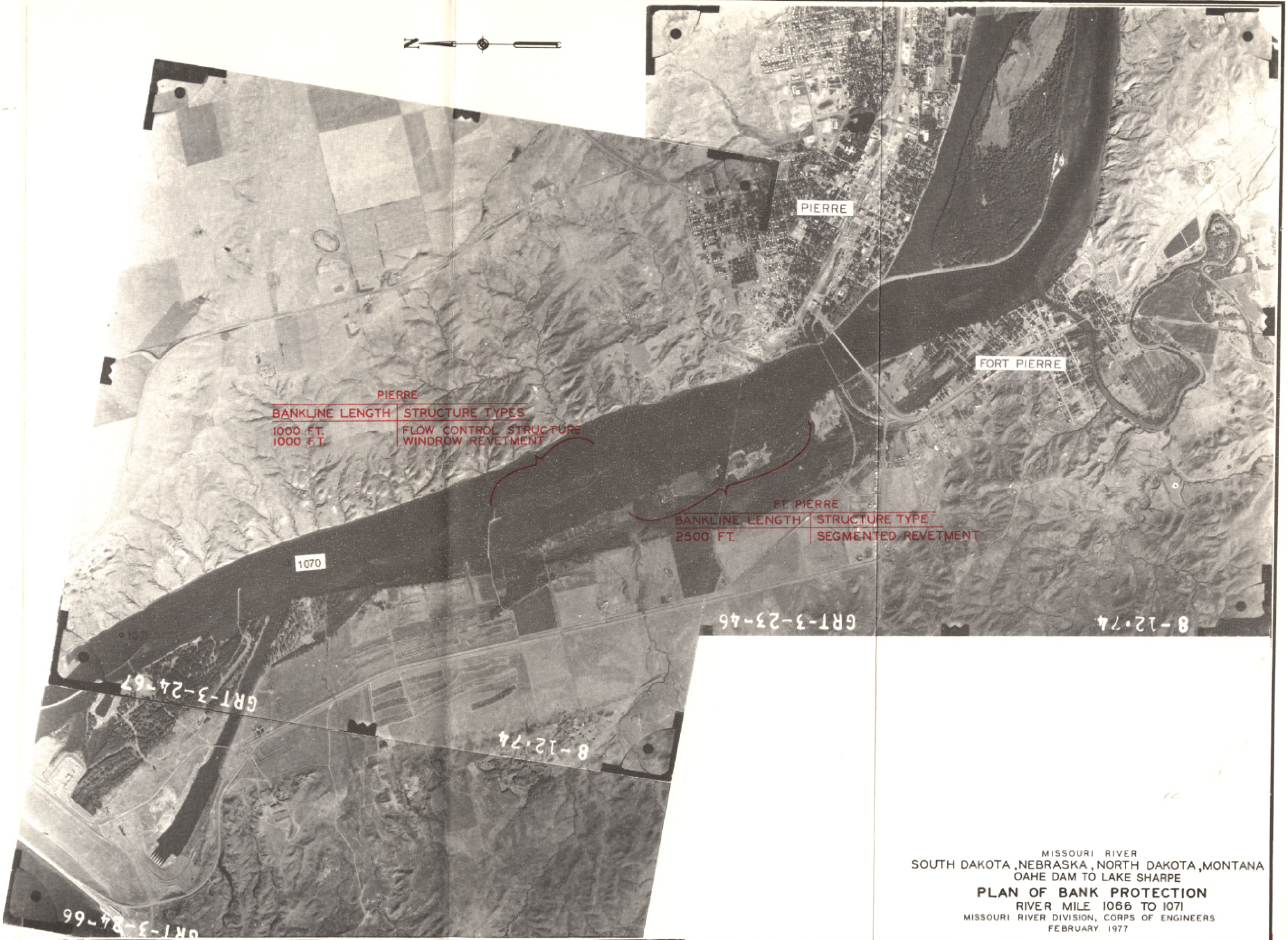
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM TO LAKE OAHE
PLAN OF BANK PROTECTION
RIVER MILE 1304 TO 1312
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

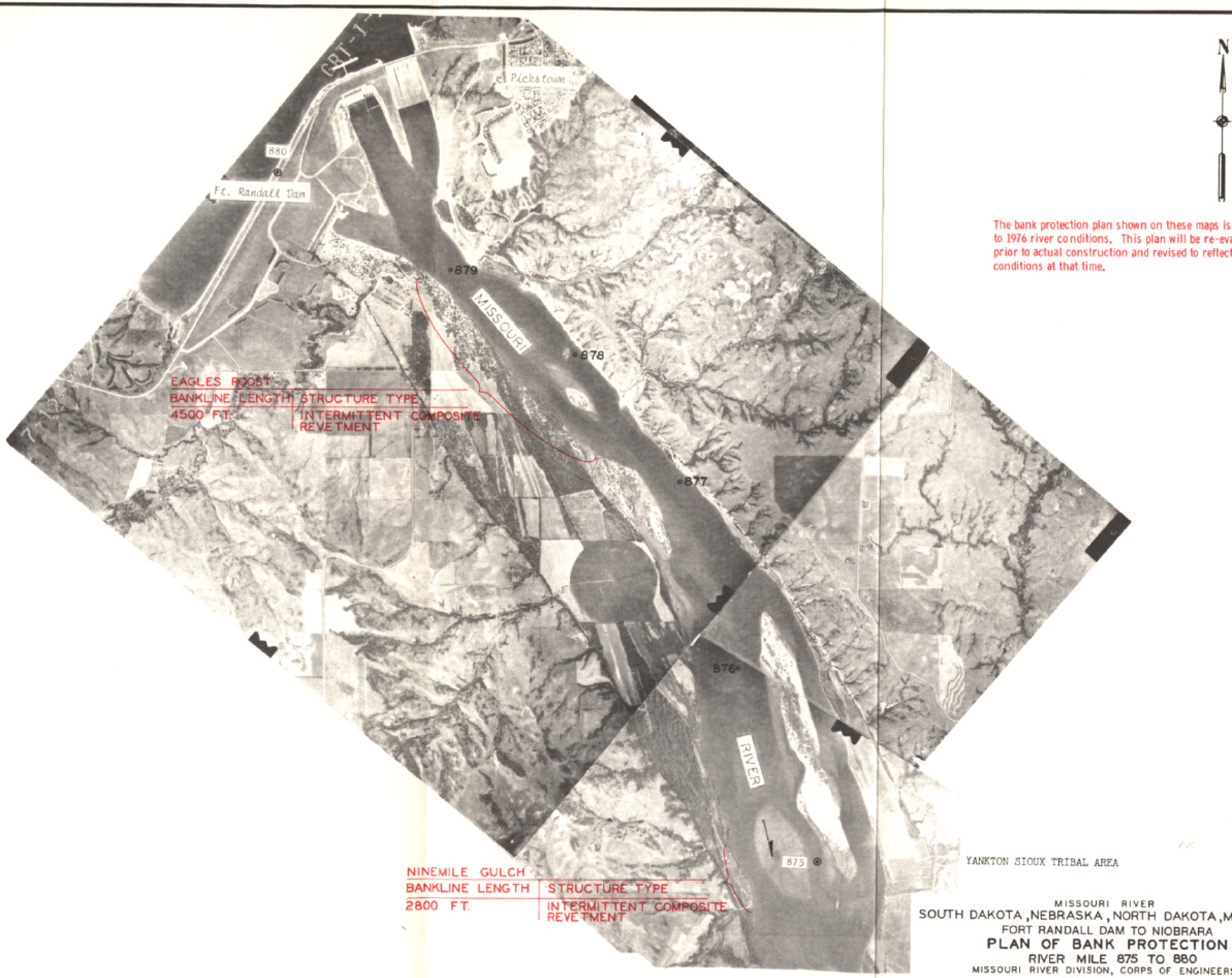


MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
OAHE DAM TO LAKE SHARPE

PLAN OF BANK PROTECTION

RIVER MILE 1066 TO 1071
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-20



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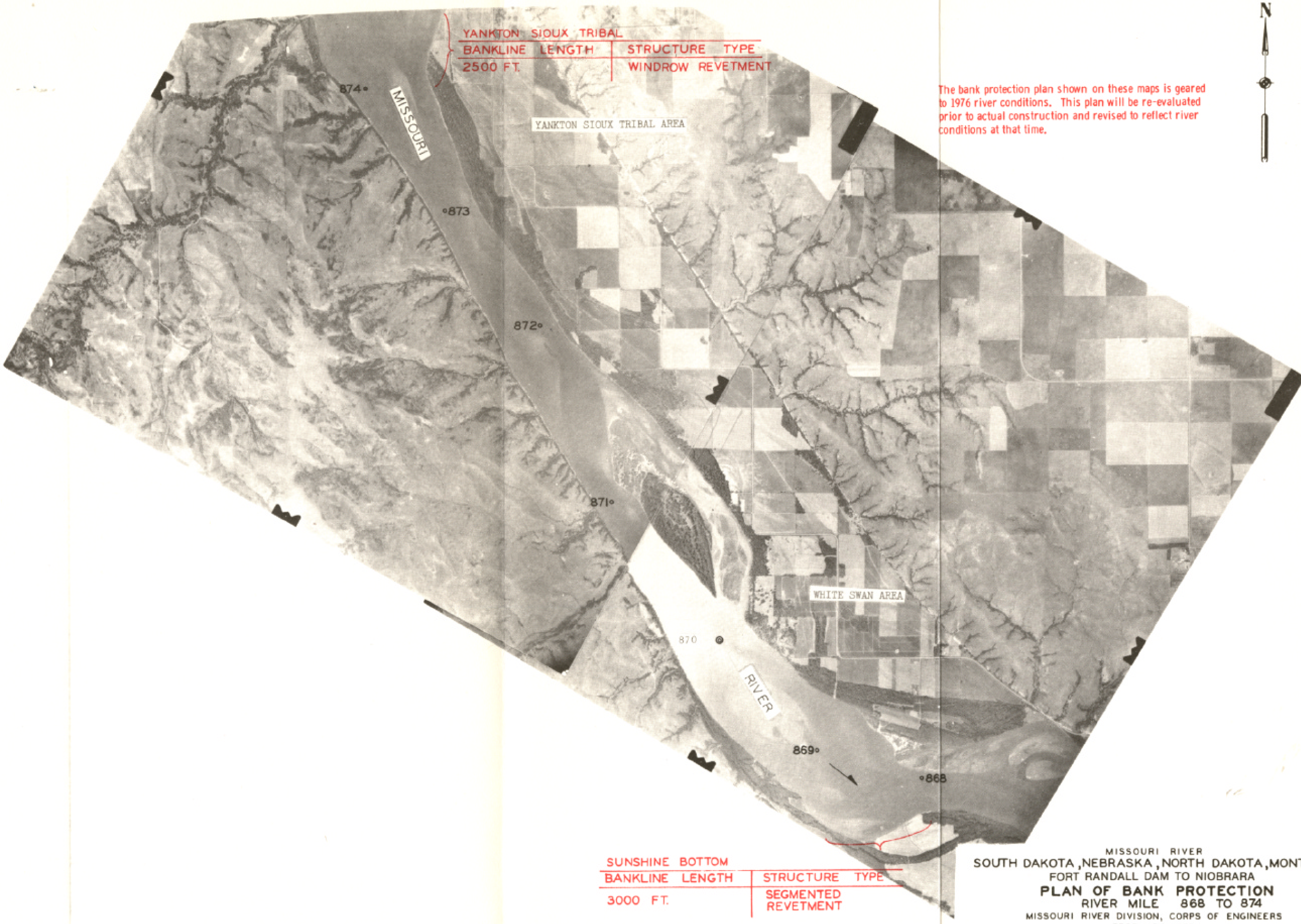
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA
PLAN OF BANK PROTECTION
RIVER MILE 875 TO 880
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



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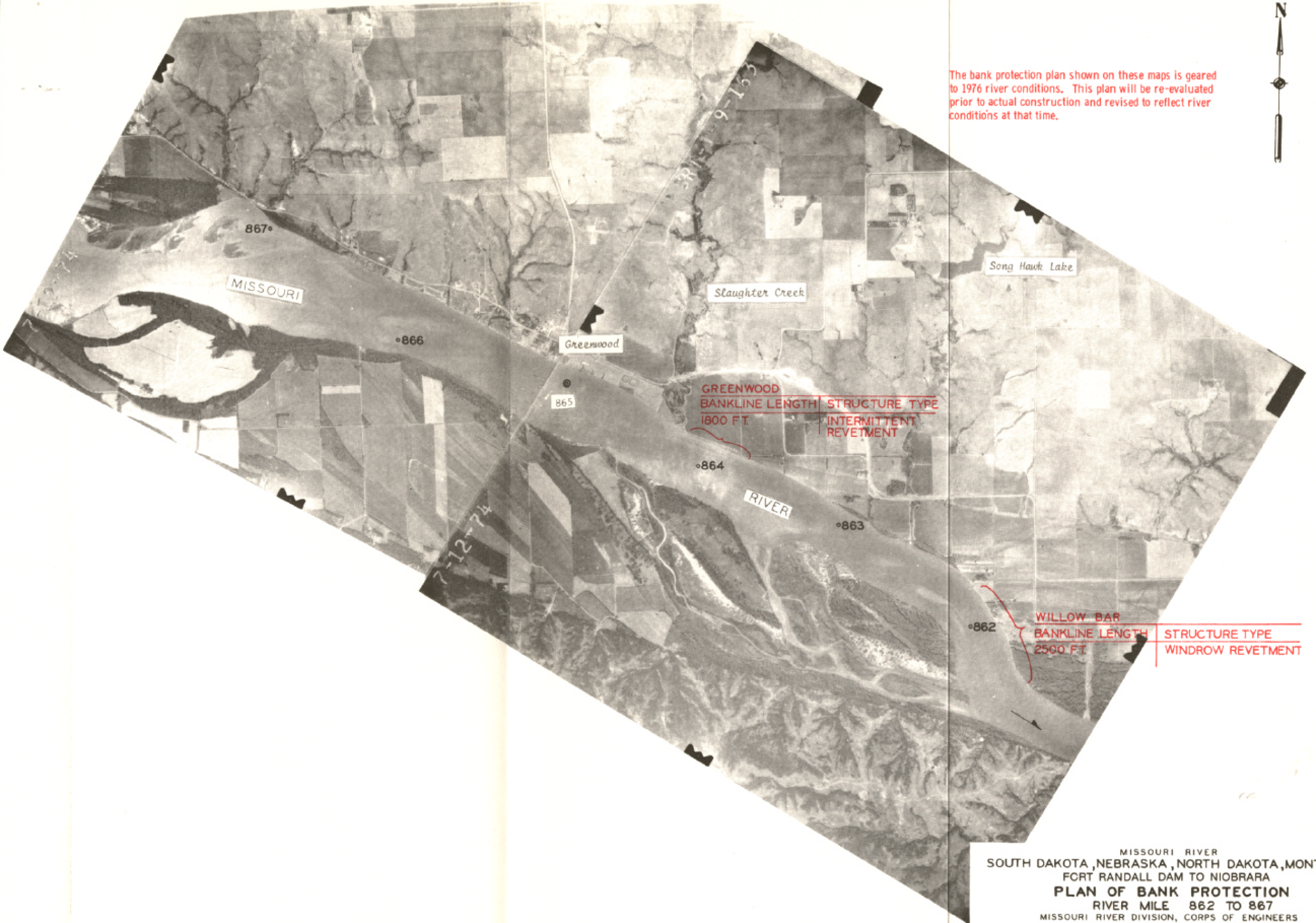
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA

PLAN OF BANK PROTECTION

RIVER MILE 868 TO 874

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.



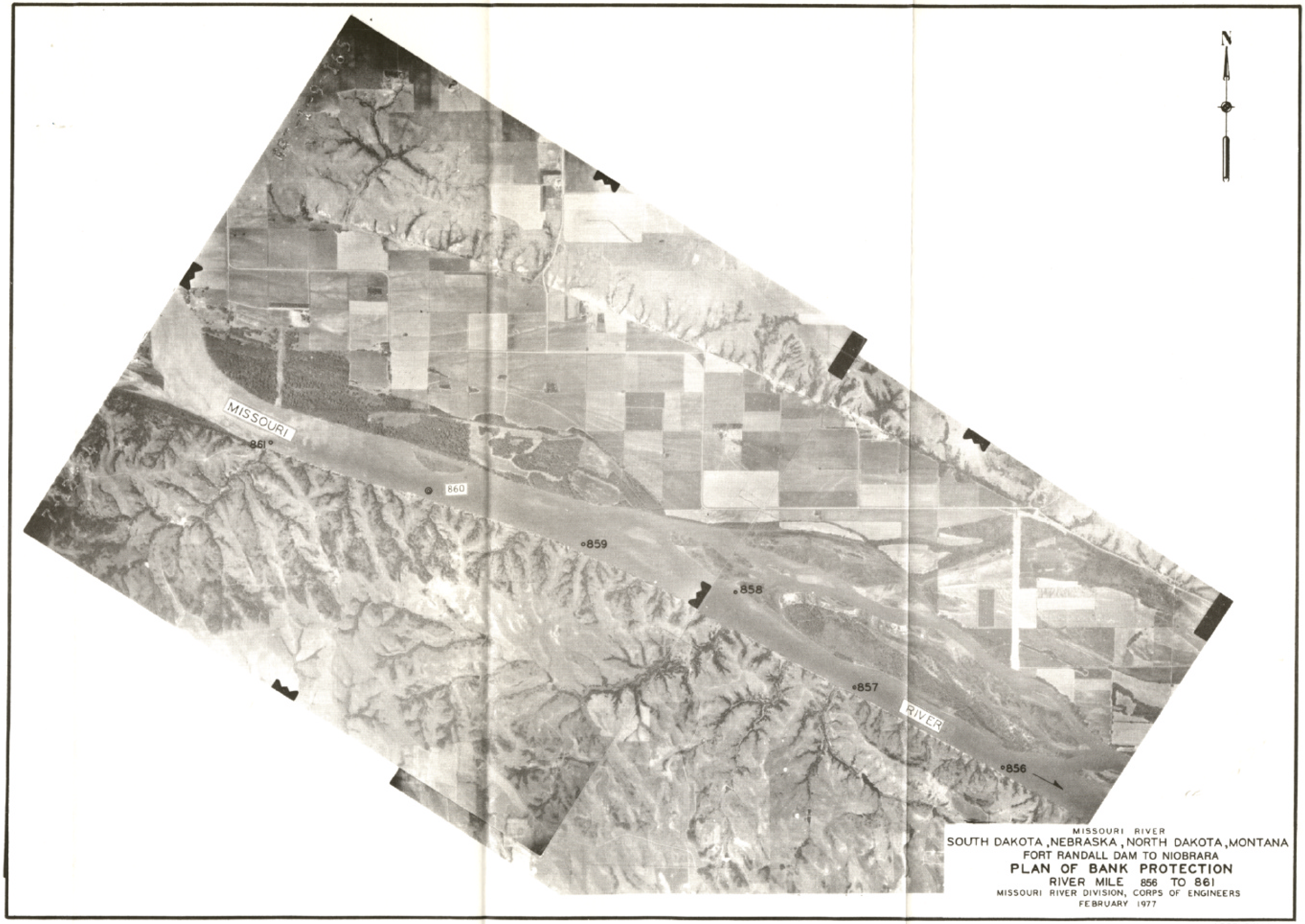
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA

PLAN OF BANK PROTECTION

RIVER MILE 862 TO 867

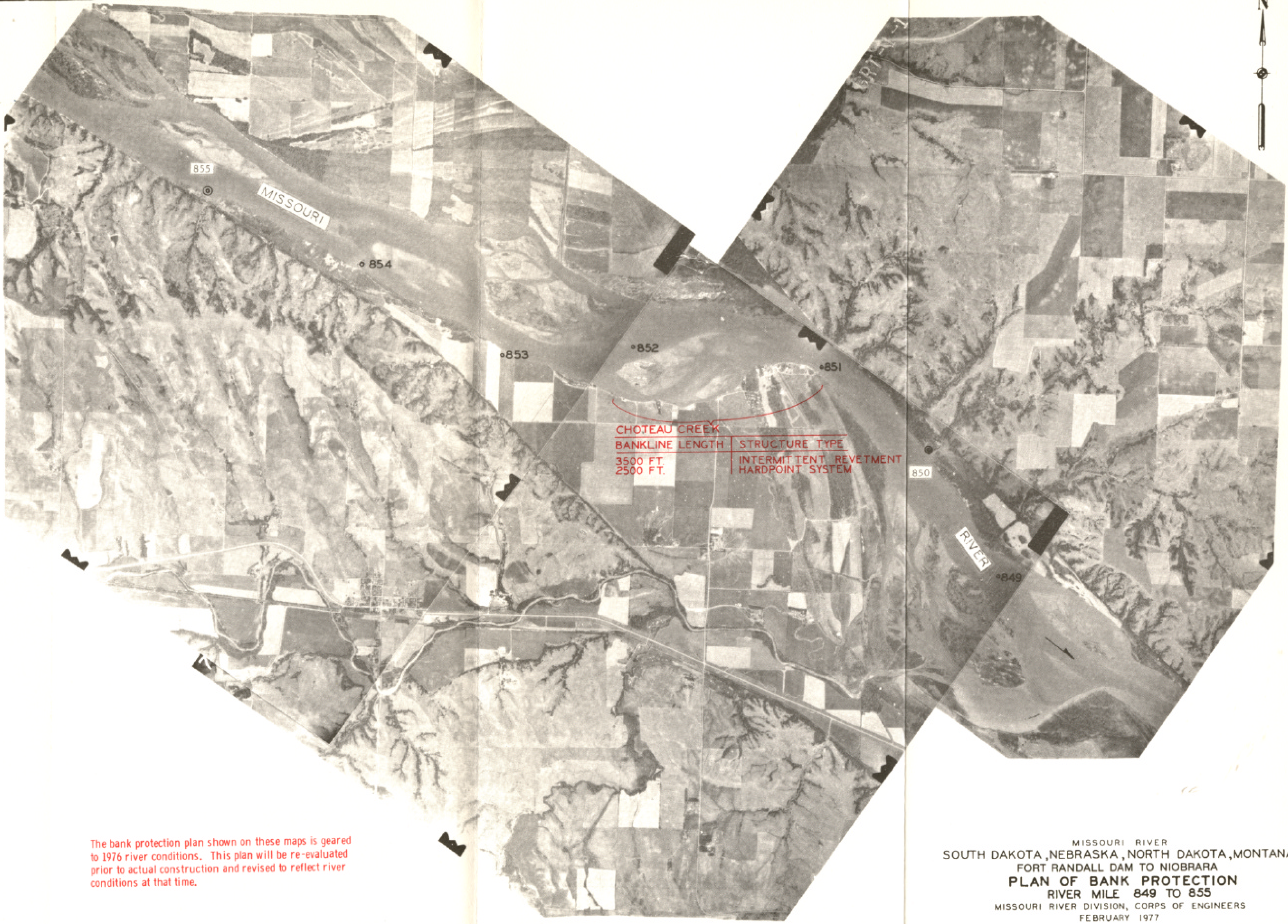
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA
PLAN OF BANK PROTECTION
RIVER MILE 856 TO 861
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-24



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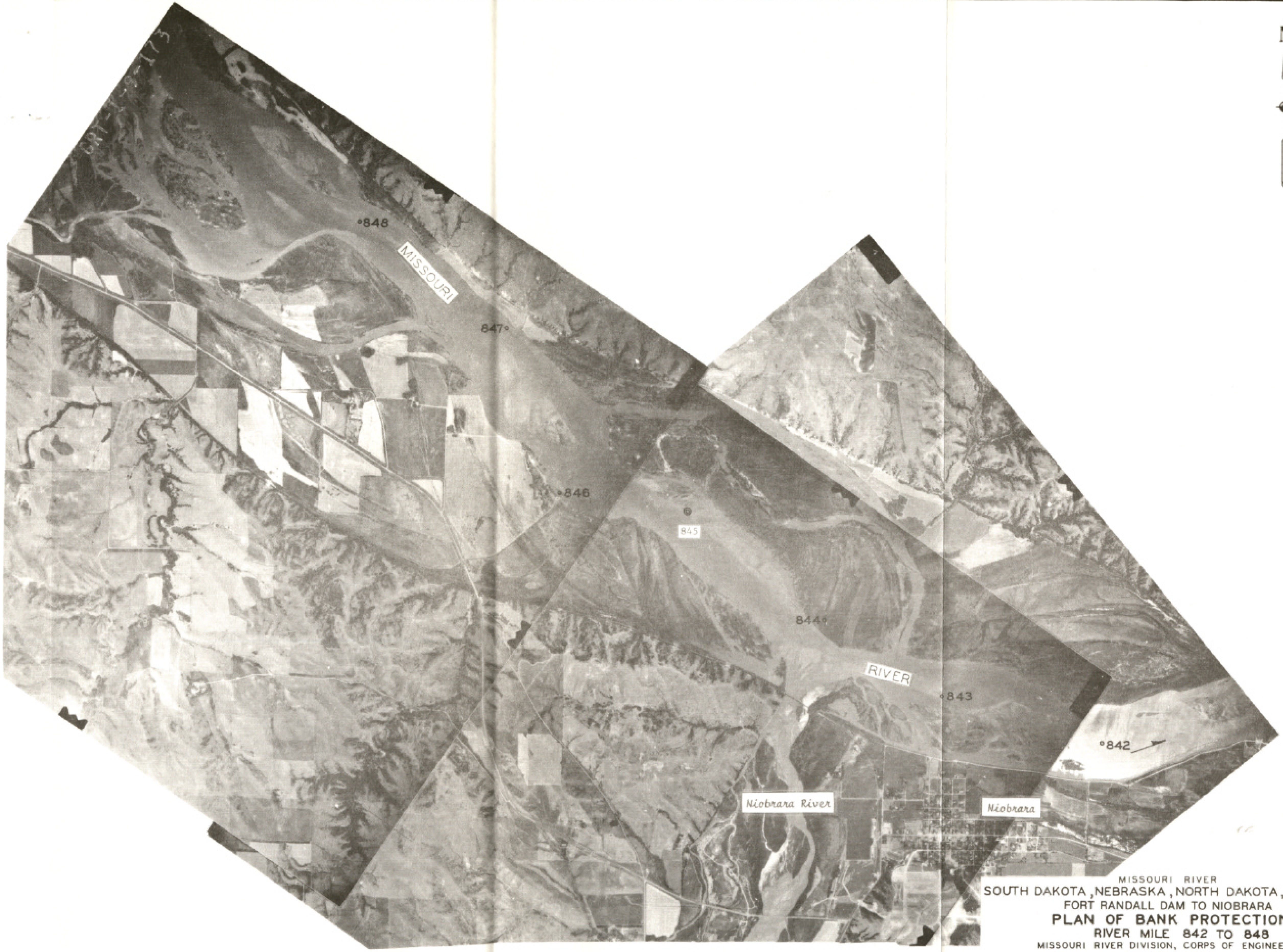
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA
PLAN OF BANK PROTECTION
RIVER MILE 849 TO 855
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

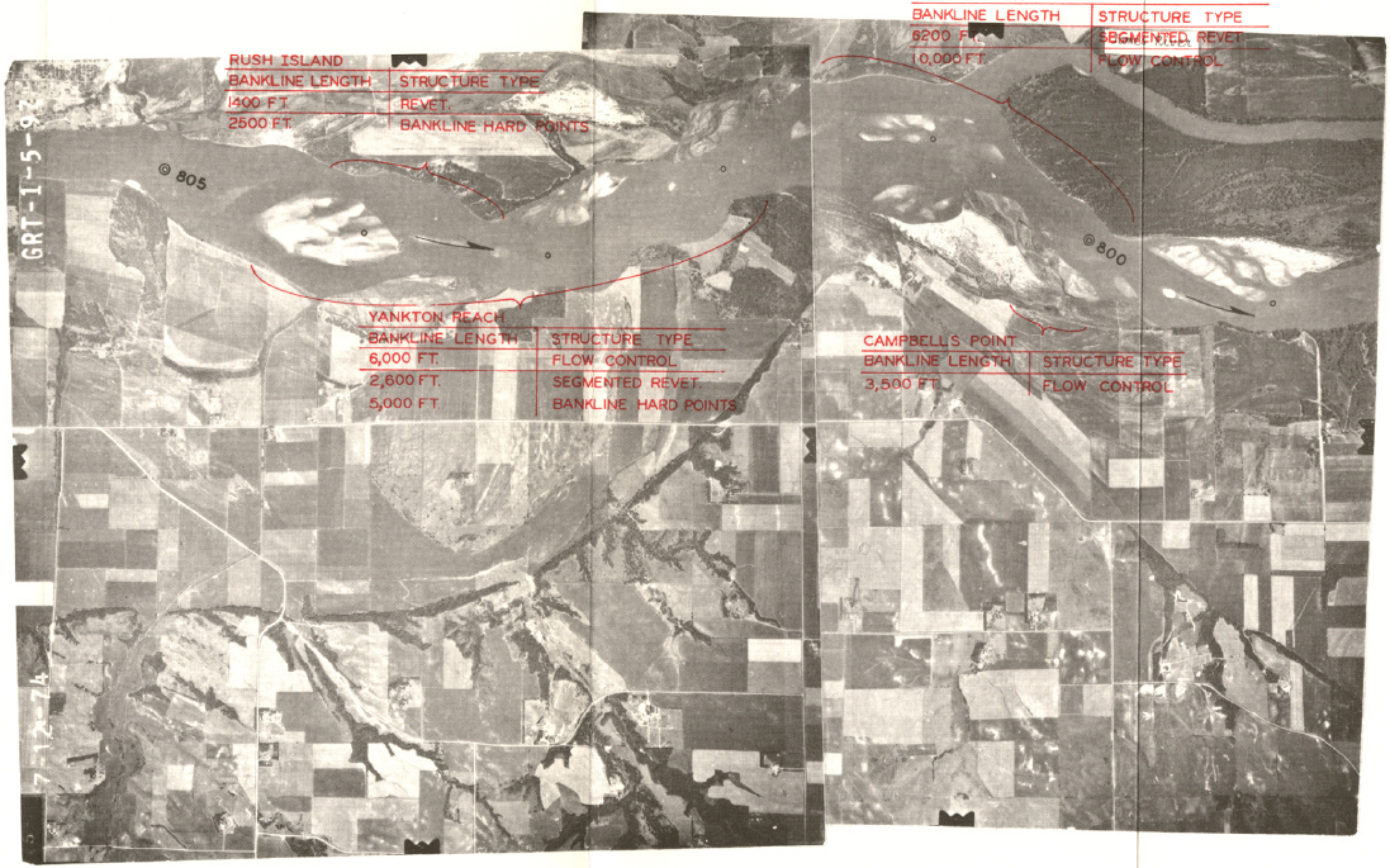
APPENDIX I
PLATE E-25



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT RANDALL DAM TO NIOBRARA
PLAN OF BANK PROTECTION
RIVER MILE 842 TO 848
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 805 TO 811
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



SCALE: 1 INCH = 2000 FEET

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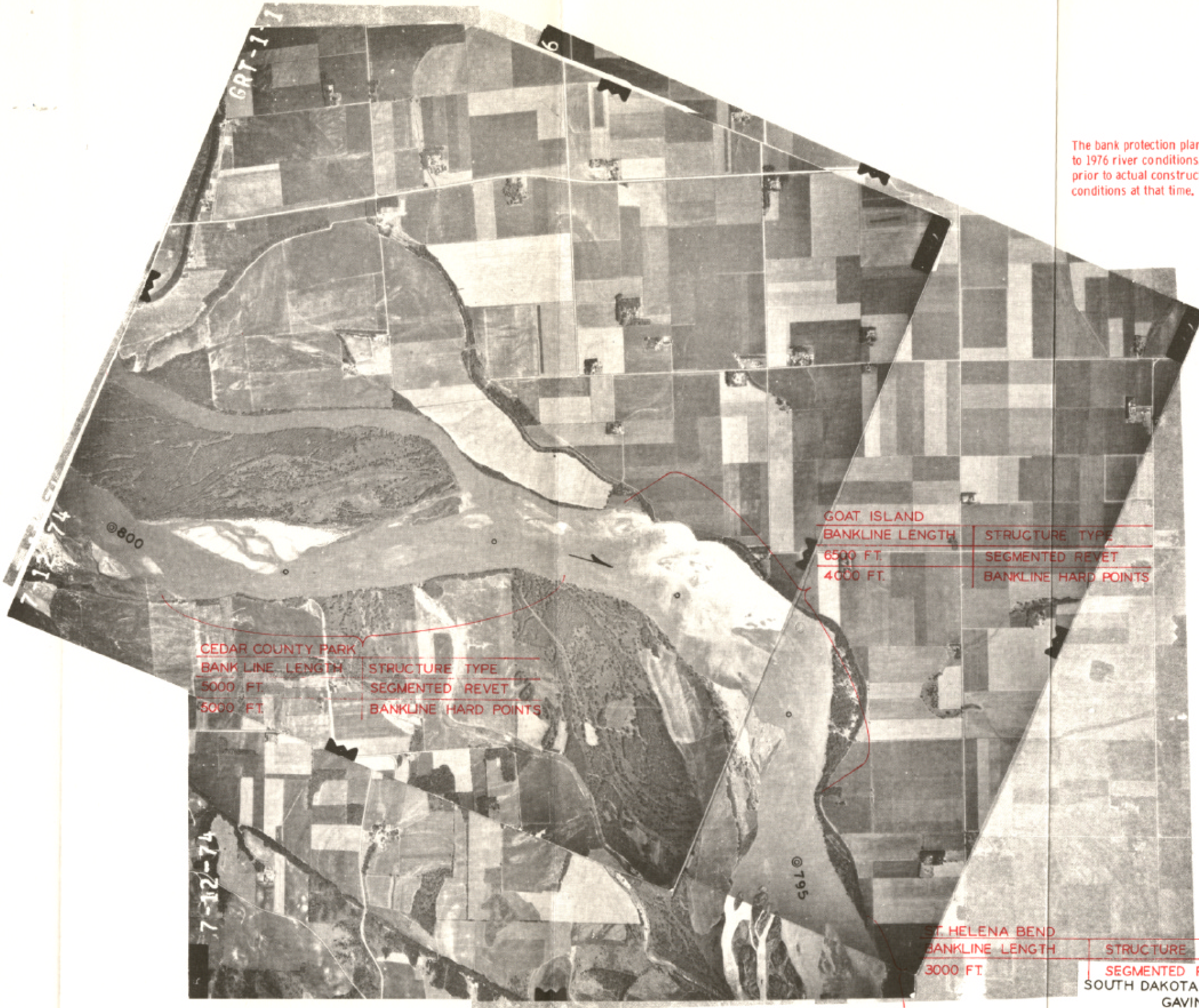
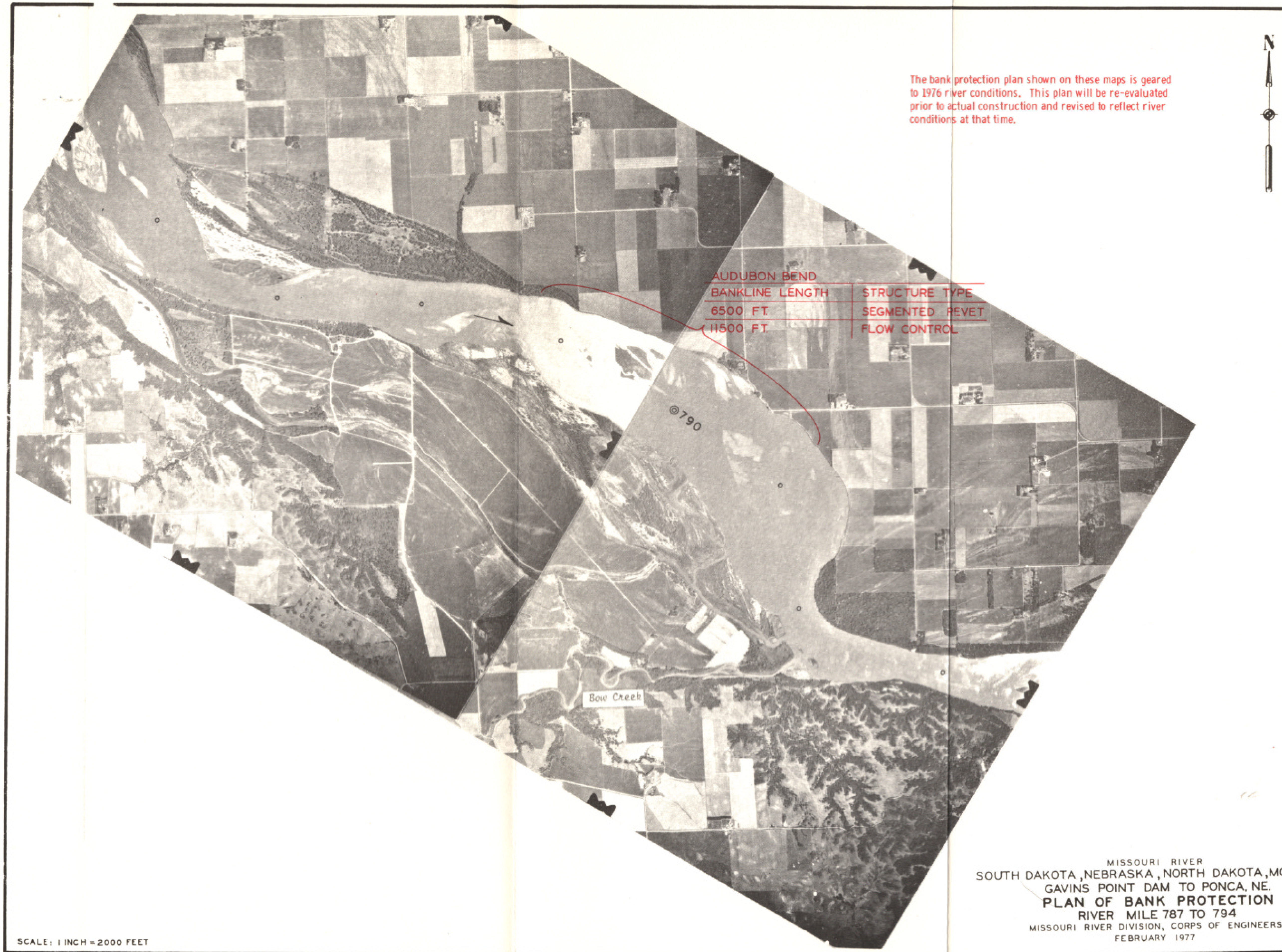
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 799 TO 805
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.



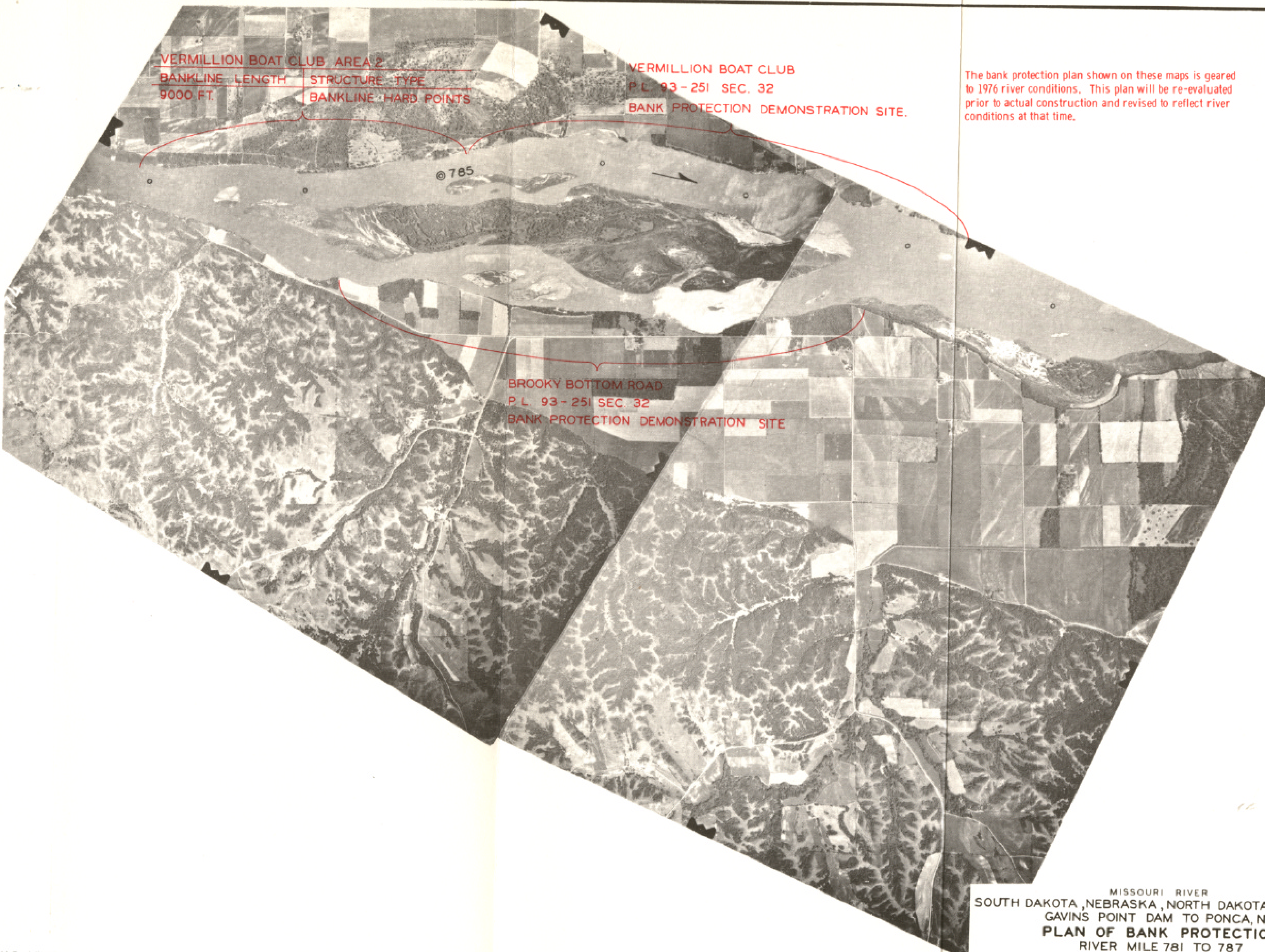
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 795 TO 799
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE 1 INCH = 2000 FEET



SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 787 TO 794
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 781 TO 787
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-31

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 772 TO 781
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

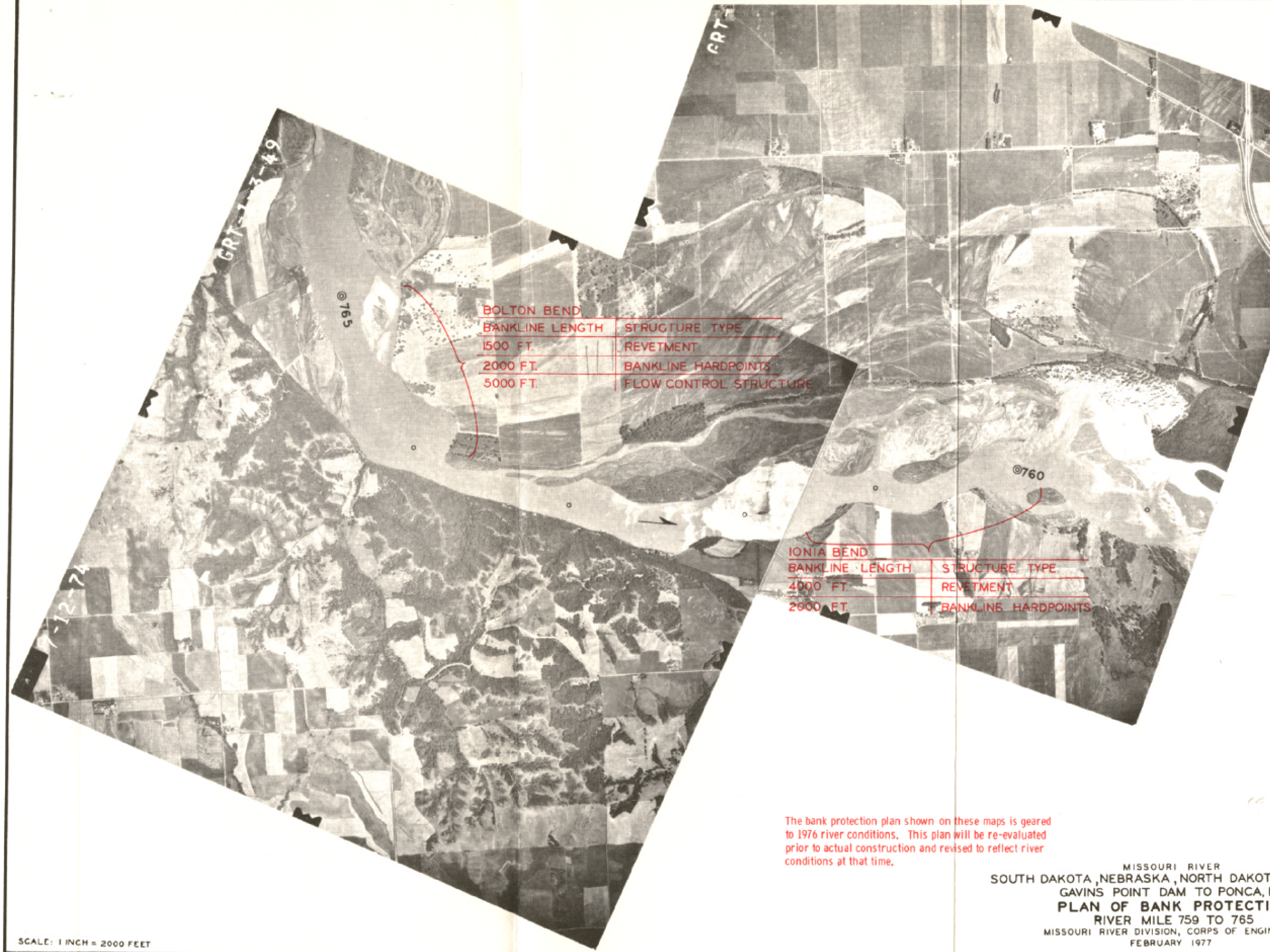
SCALE: 1 INCH = 2000 FEET

The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 765 TO 772
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE: 1 INCH = 2000 FEET

APPENDIX I
PLATE E- 33



The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

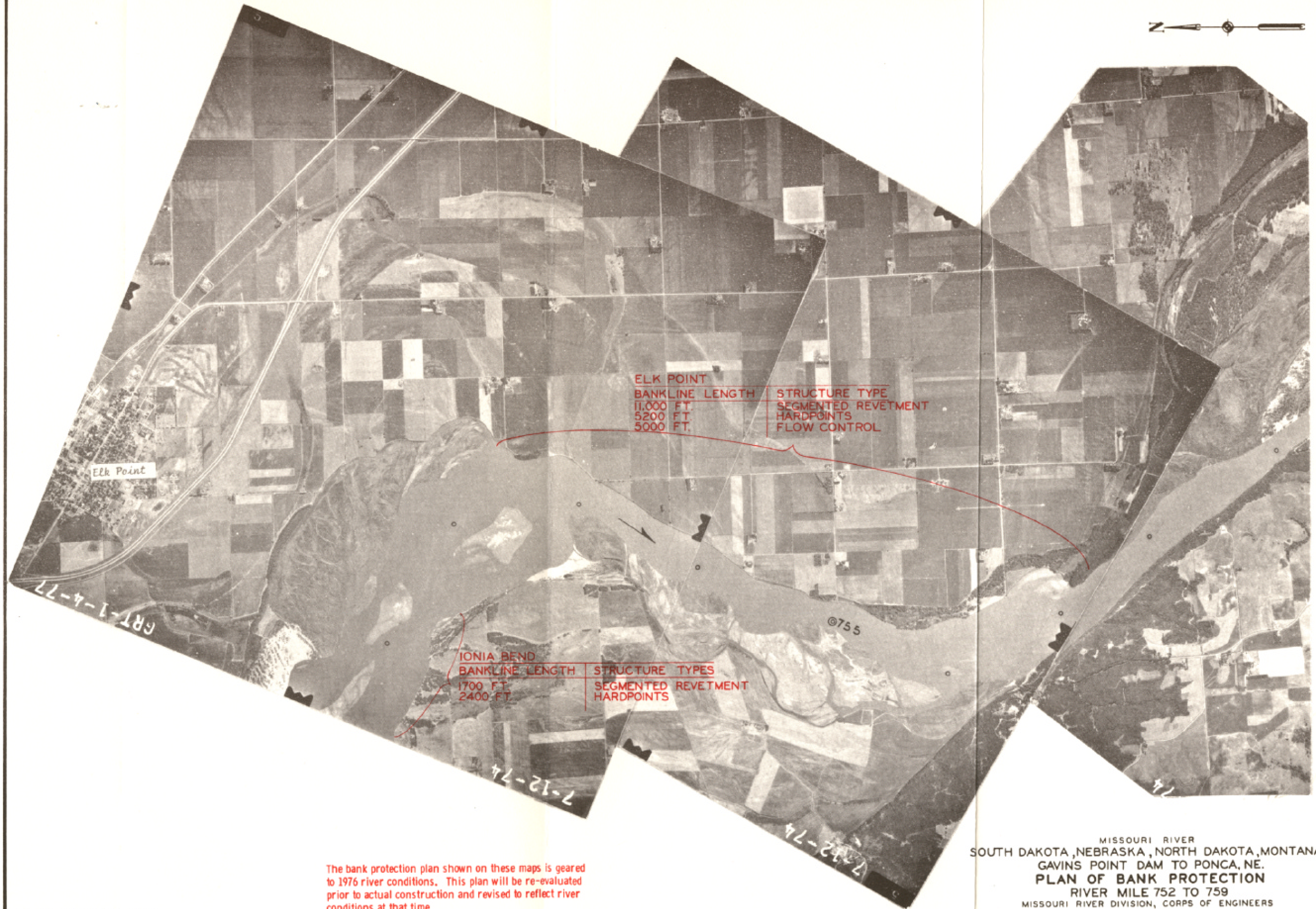
SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.

PLAN OF BANK PROTECTION

RIVER MILE 759 TO 765

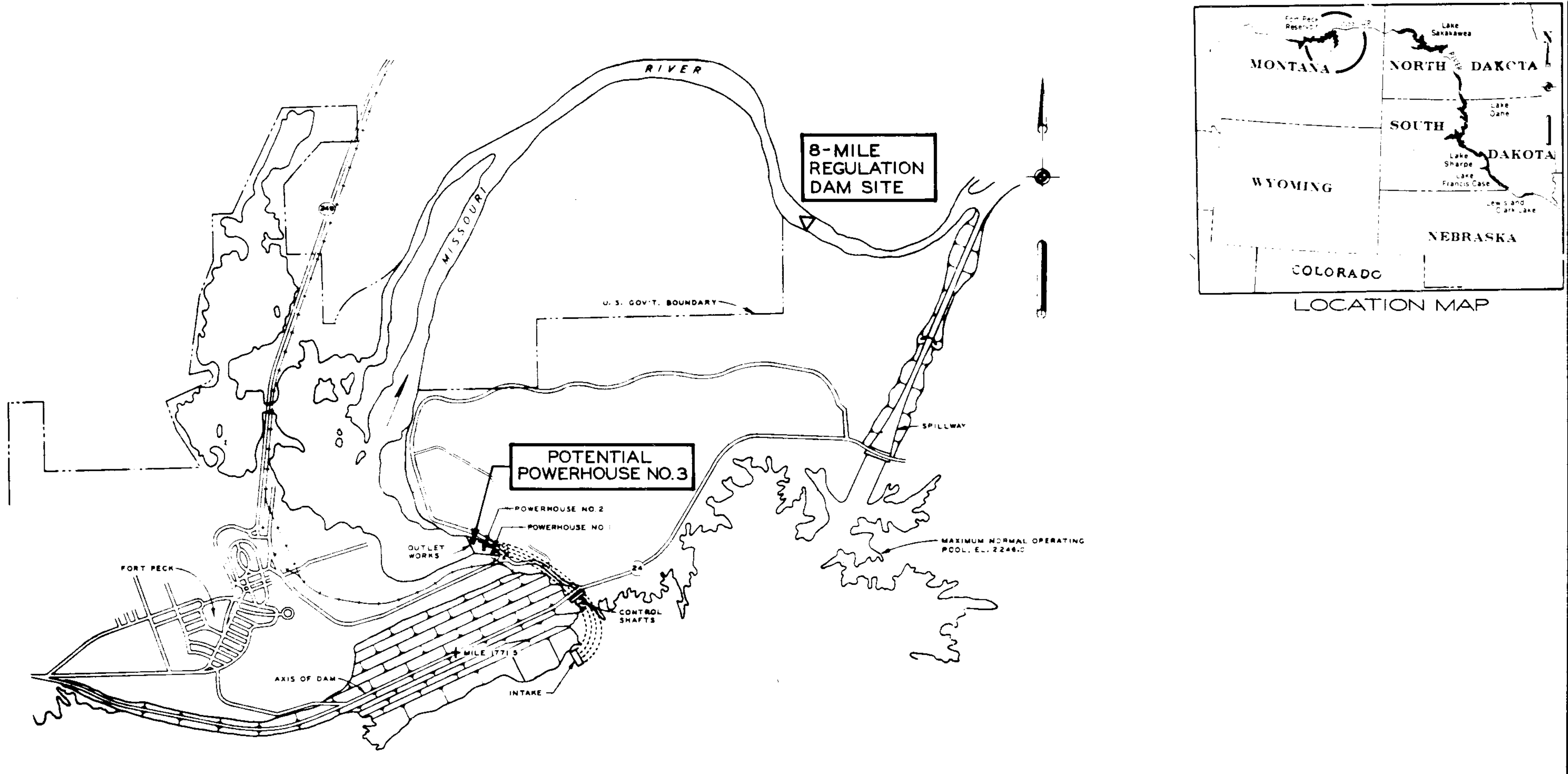
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



The bank protection plan shown on these maps is geared to 1976 river conditions. This plan will be re-evaluated prior to actual construction and revised to reflect river conditions at that time.

SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF BANK PROTECTION
RIVER MILE 752 TO 759
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



GENERAL PLAN

1500' 0 1500'

MISSOURI RIVER

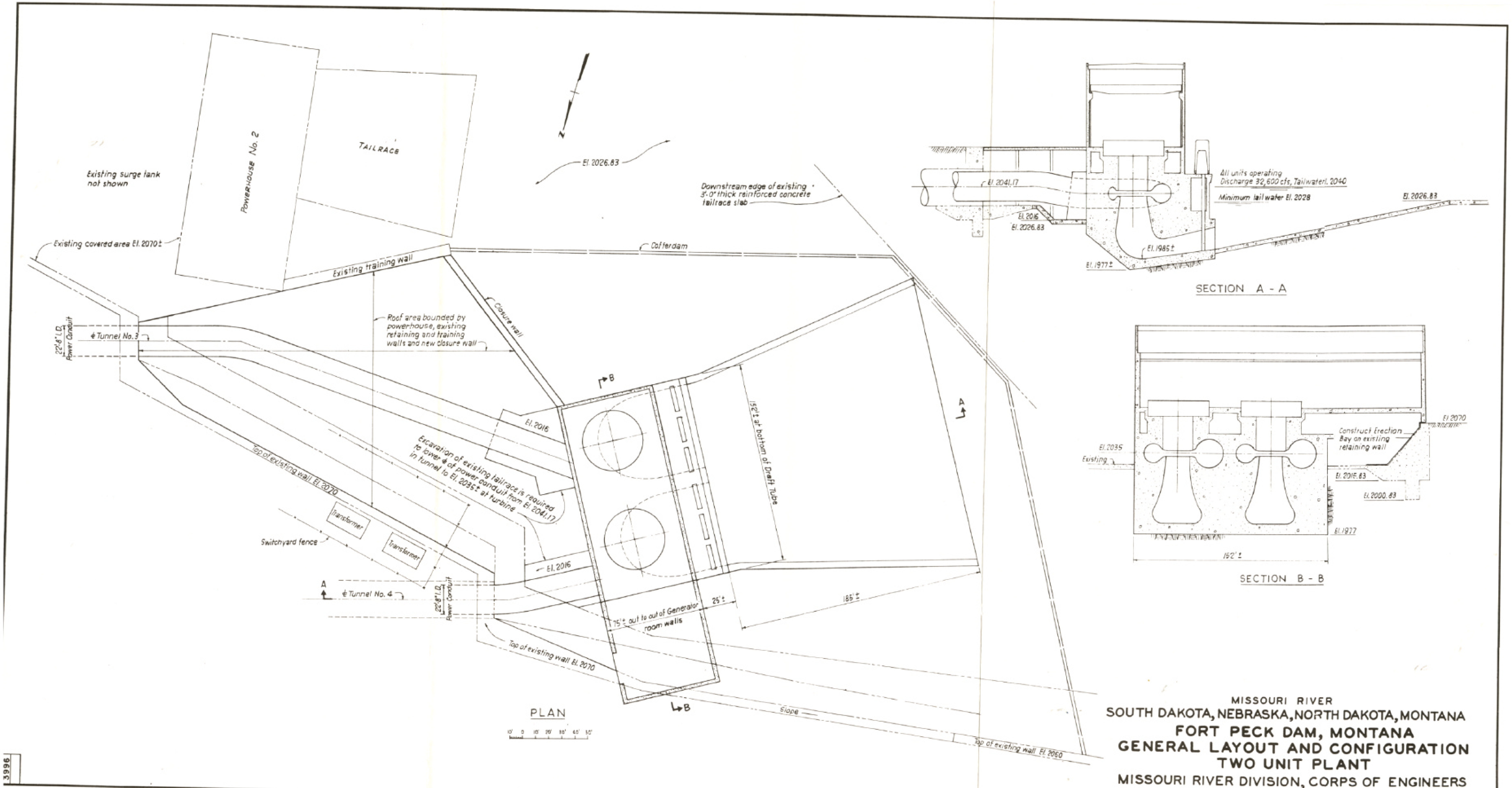
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

FORT PECK DAM

SITE PLAN

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977



MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

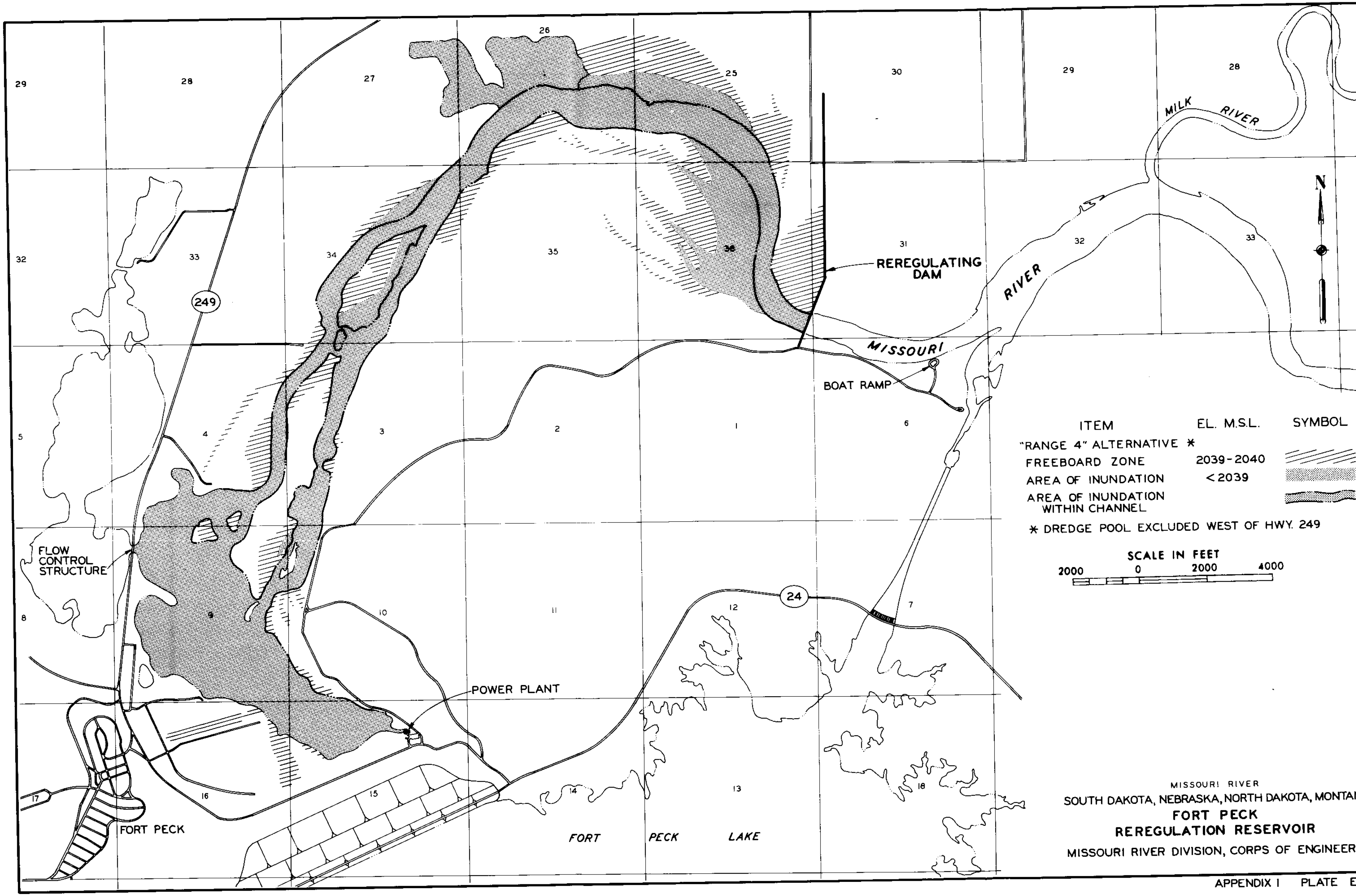
FORT PECK DAM, MONTANA

GENERAL LAYOUT AND CONFIGURATION

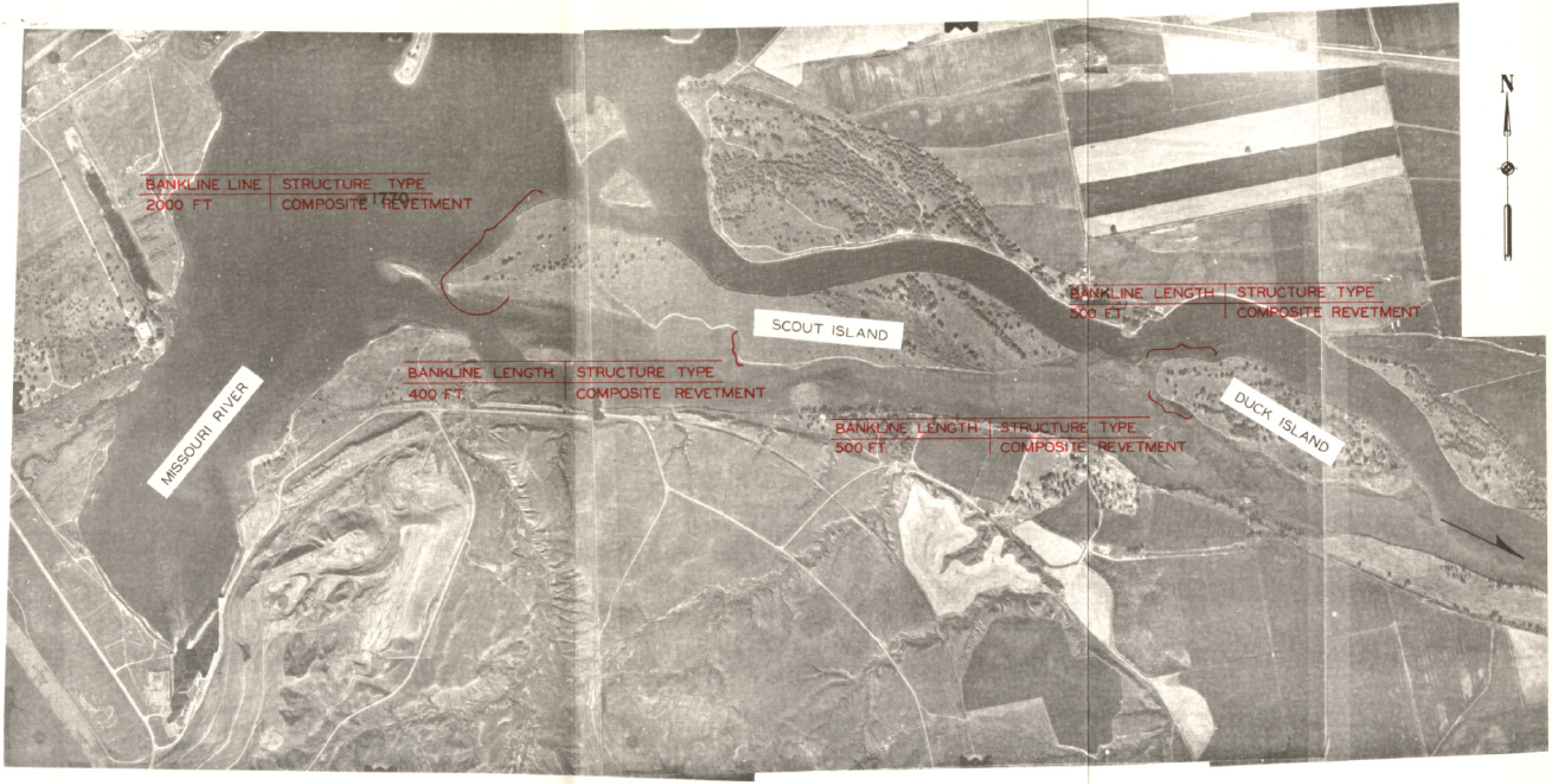
TWO UNIT PLANT

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977



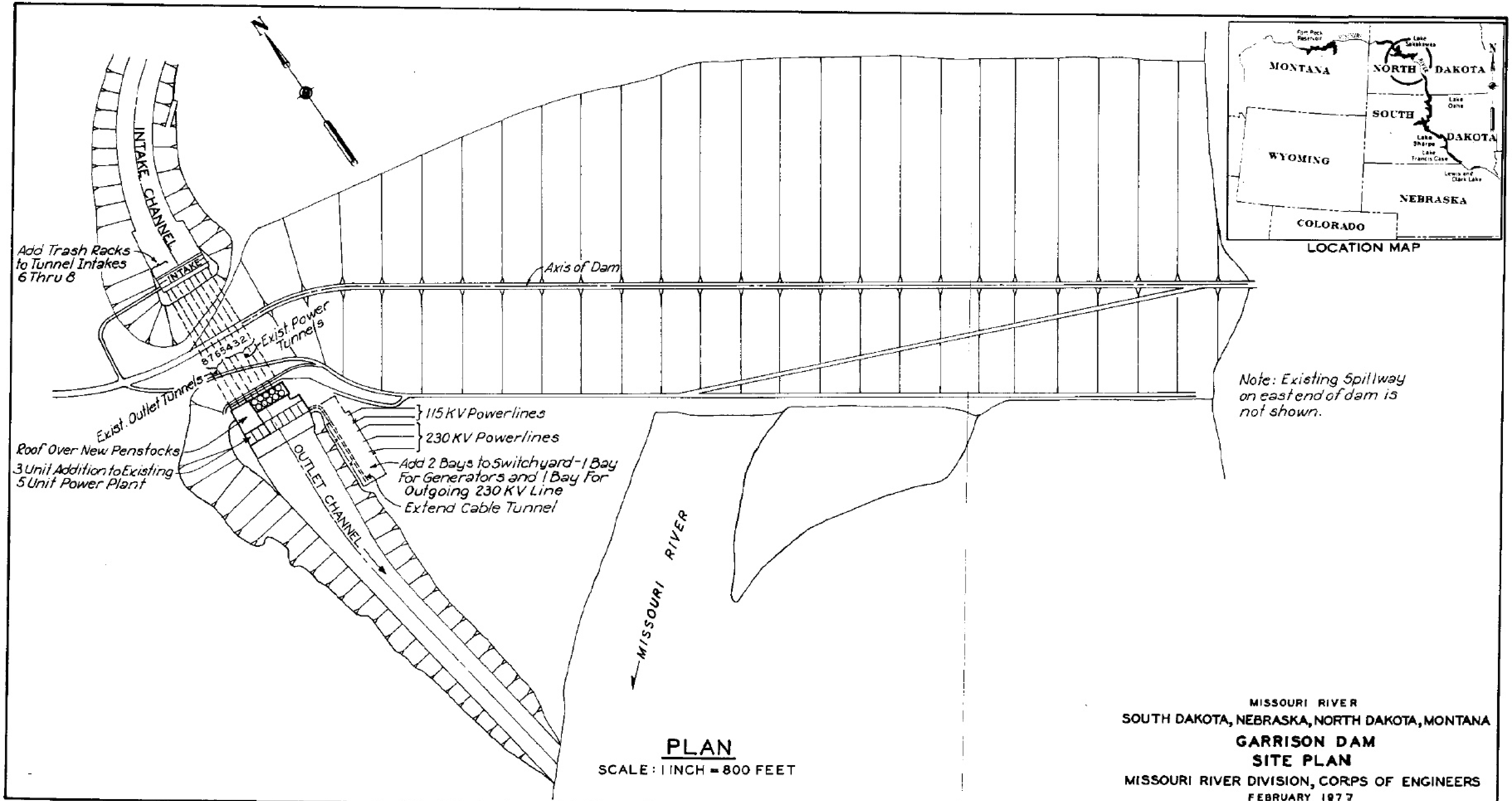
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
FORT PECK
REREGULATION RESERVOIR
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

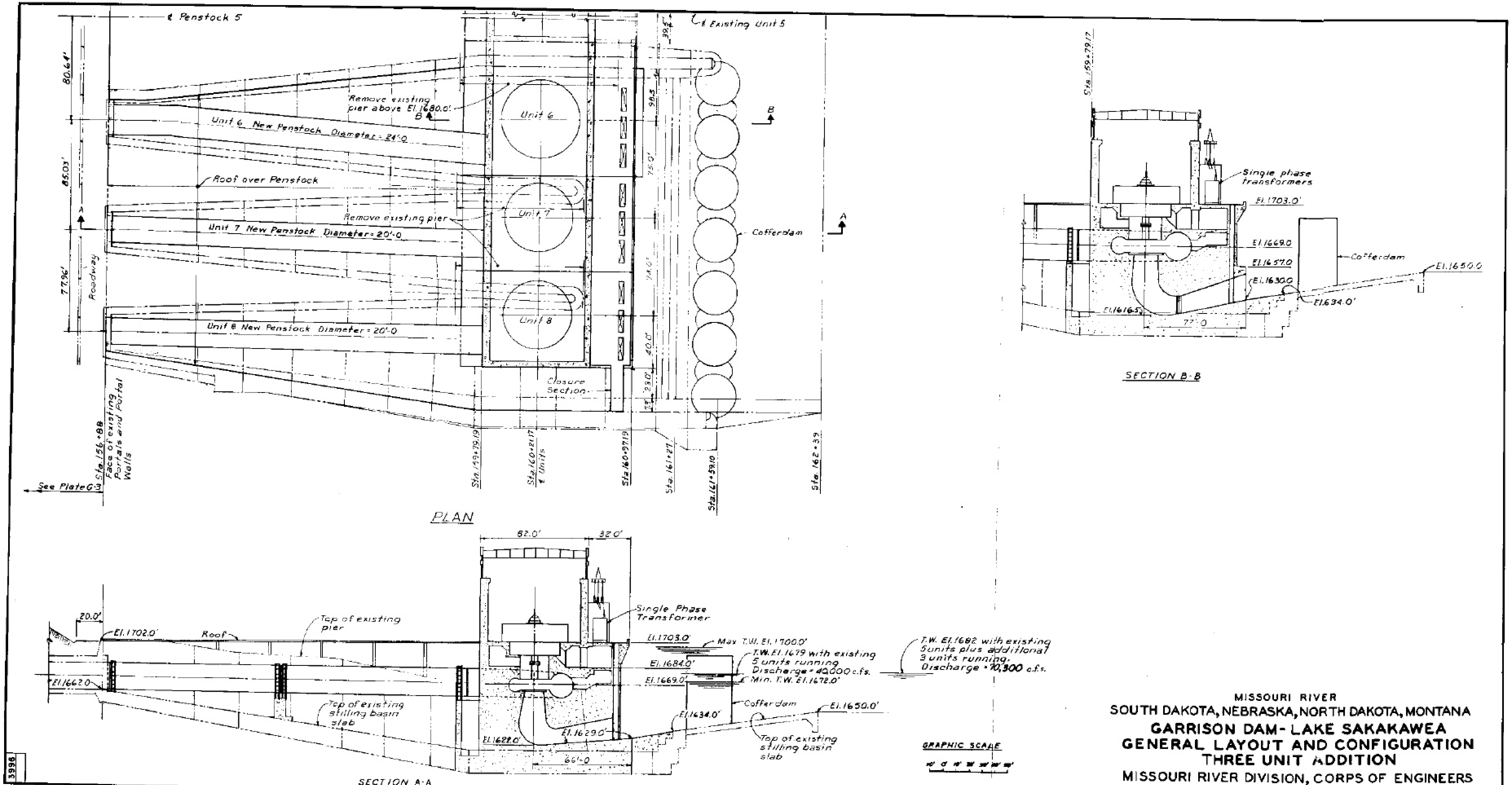
FORT PECK MITIGATION
FOR ADDITIONAL HYDRO-POWER

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



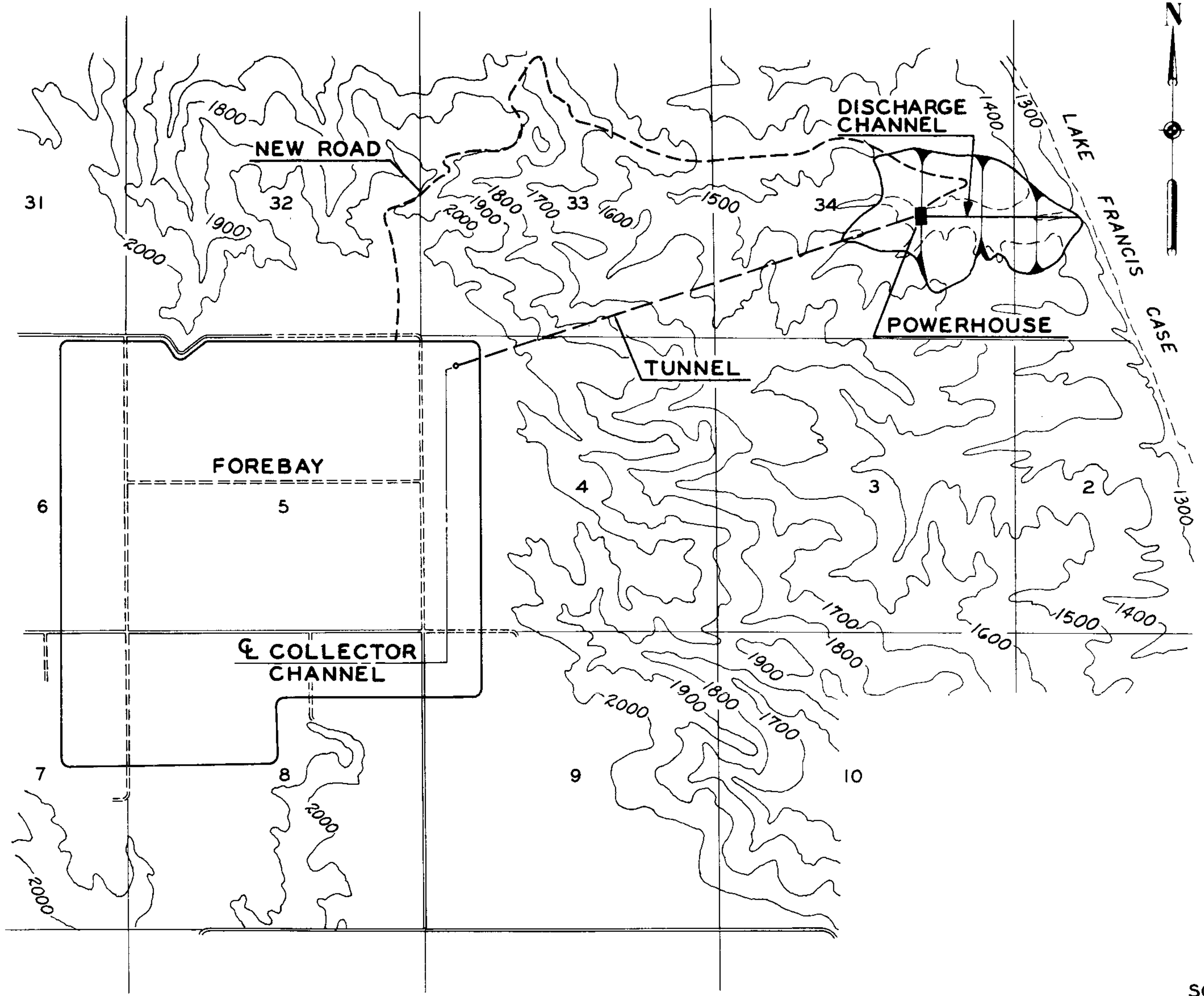
PLAN
SCALE: 1 INCH = 800 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM
SITE PLAN
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GARRISON DAM - LAKE SAKAKAWEA
GENERAL LAYOUT AND CONFIGURATION
THREE UNIT ADDITION
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-41



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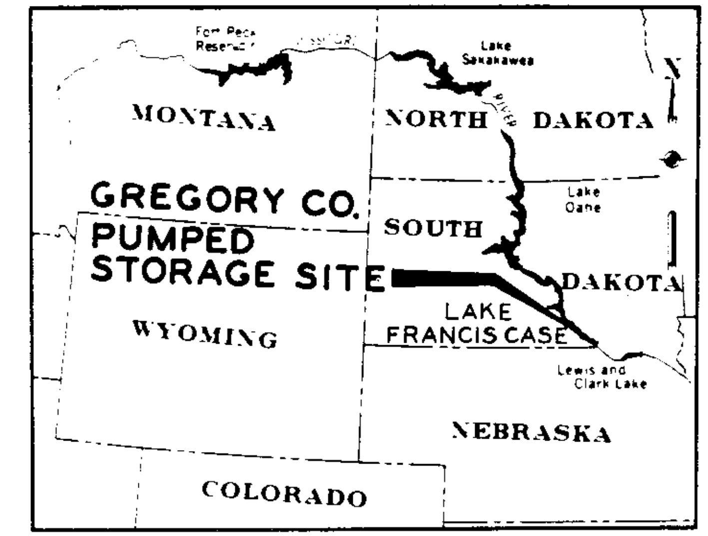
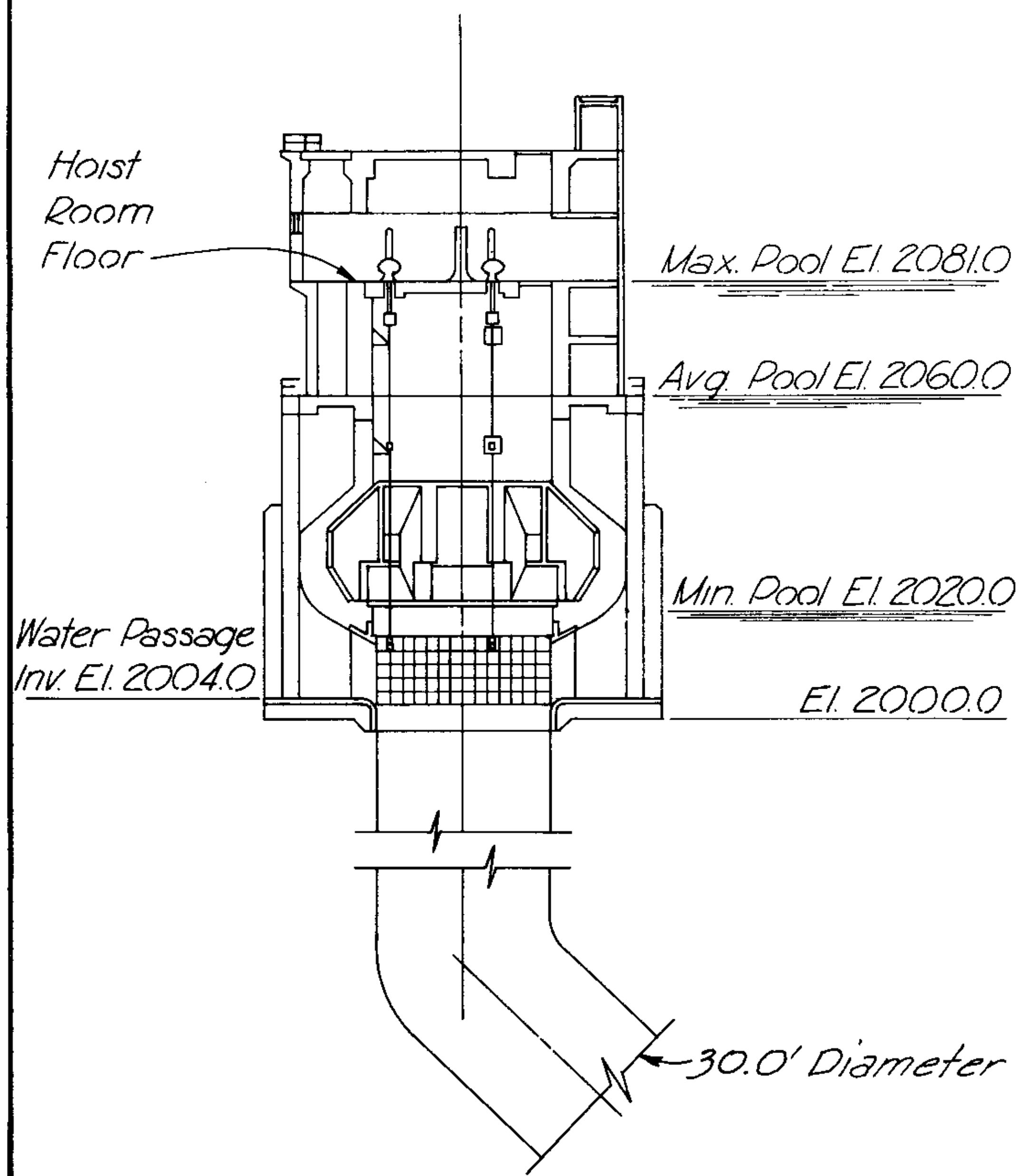


LOCATION MAP

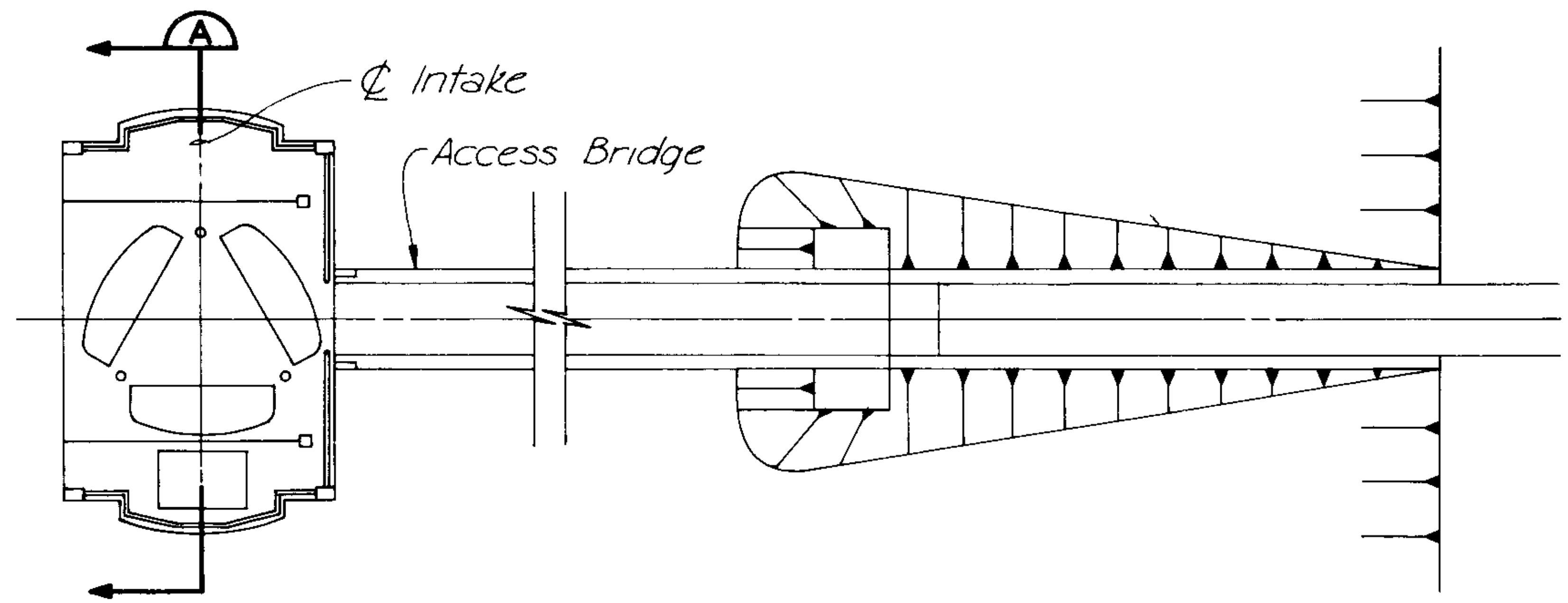
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

GREGORY COUNTY
PUMPED STORAGE PLAN

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

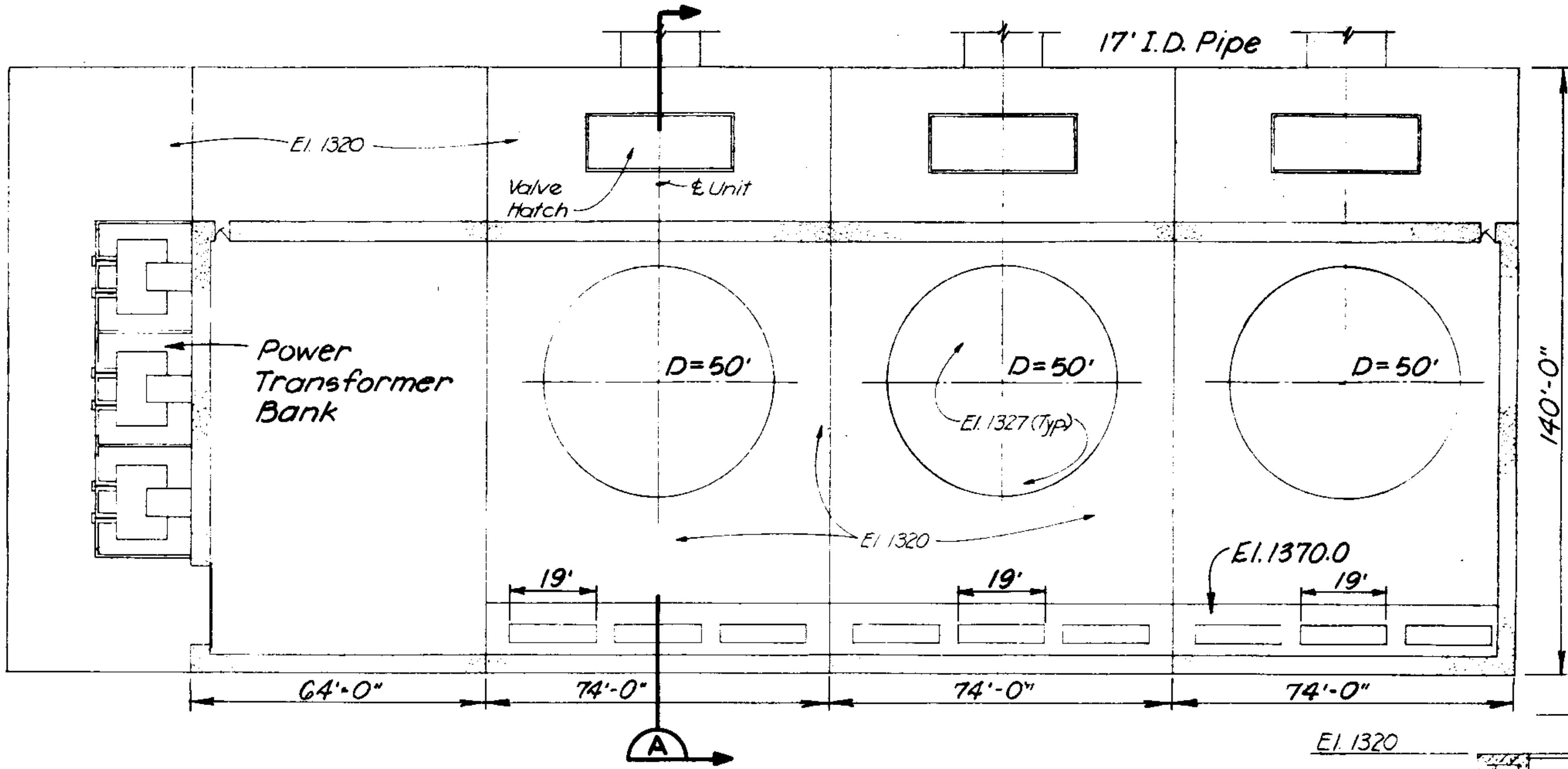


SECTION (A)



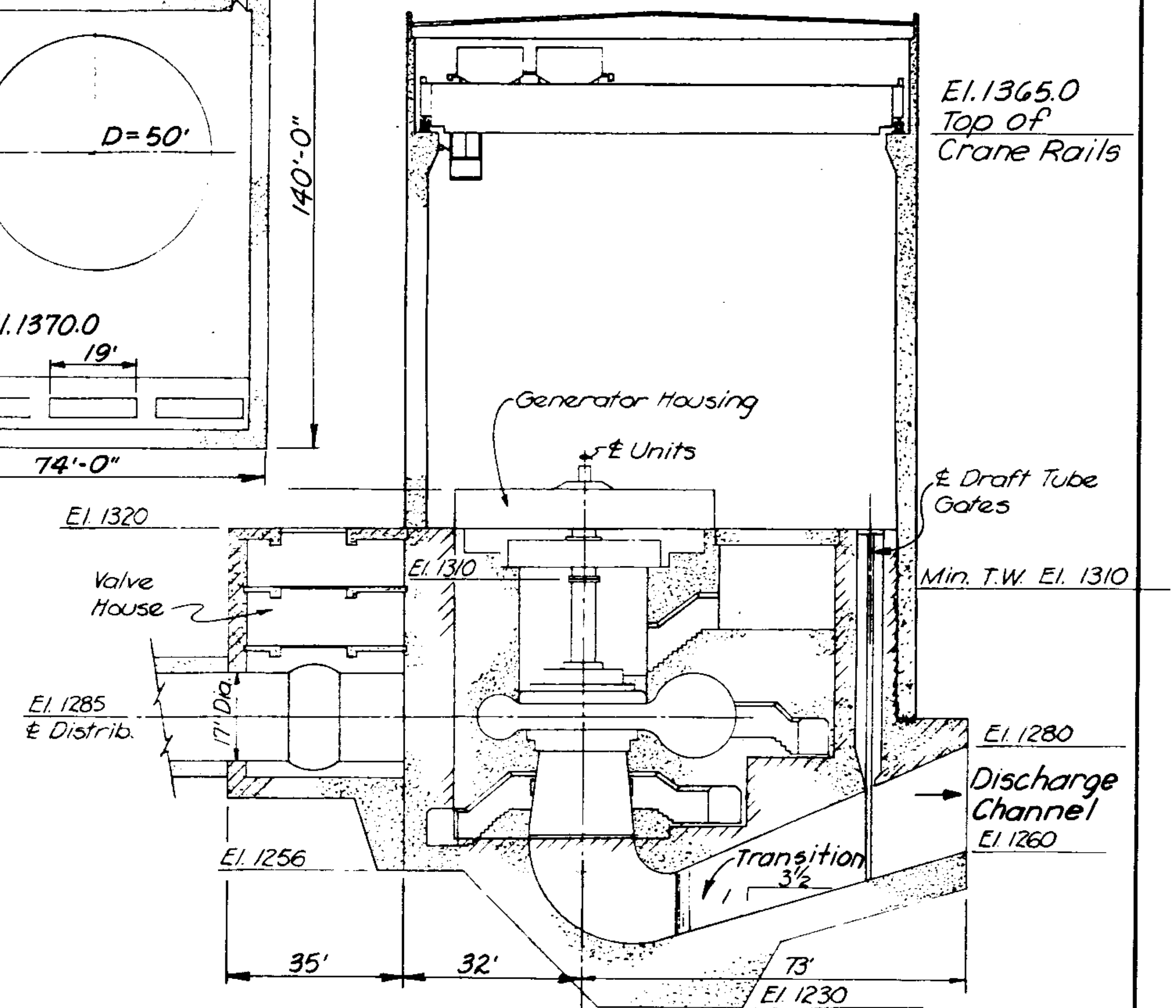
PLAN

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GREGORY COUNTY PUMPED STORAGE PROJECT
FOREBAY INTAKE
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



PLAN VIEW OF POWERHOUSE

NO SCALE



SECTION A

NO SCALE

MISSOURI RIVER

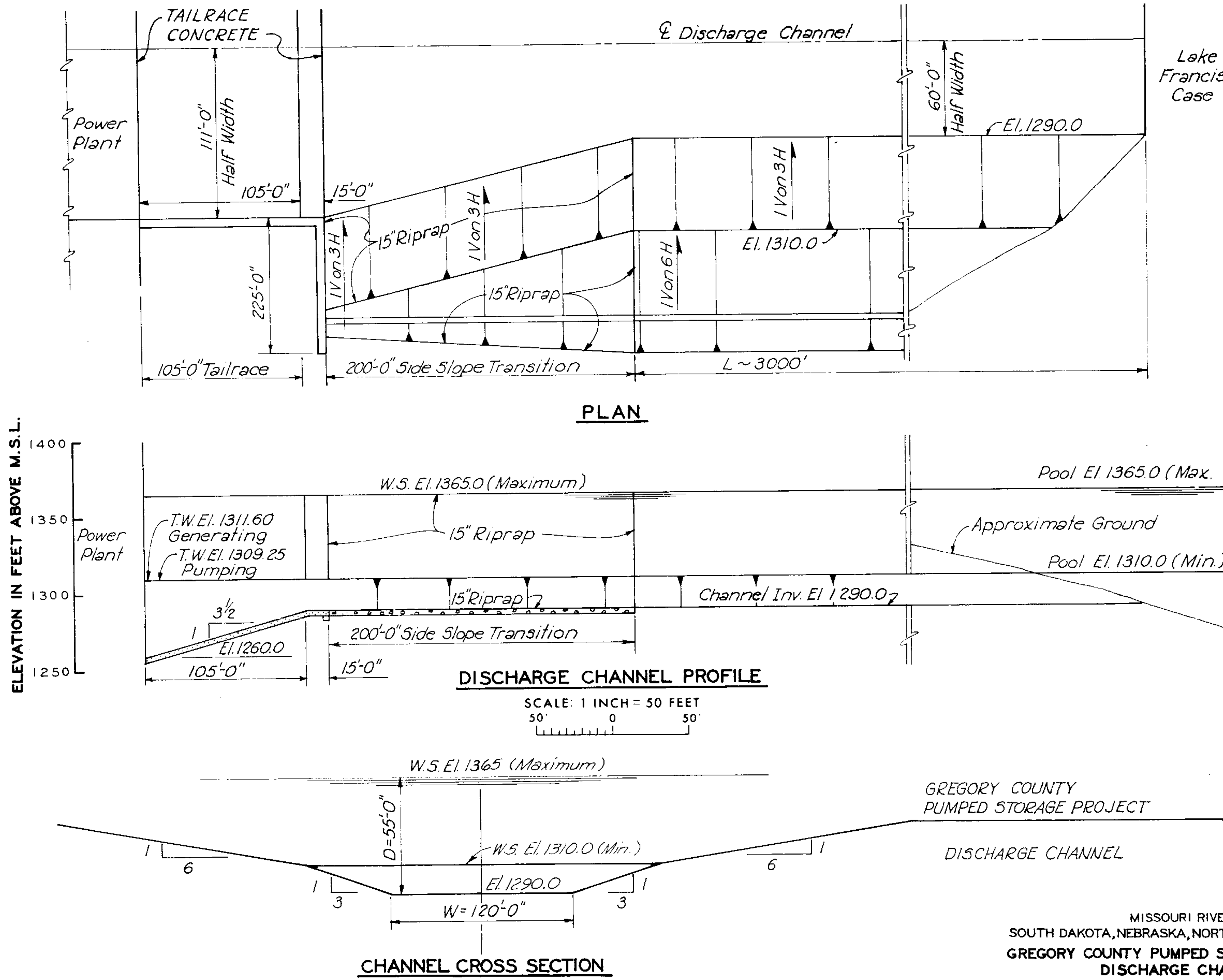
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA

GREGORY COUNTY PUMPED STORAGE PROJECT

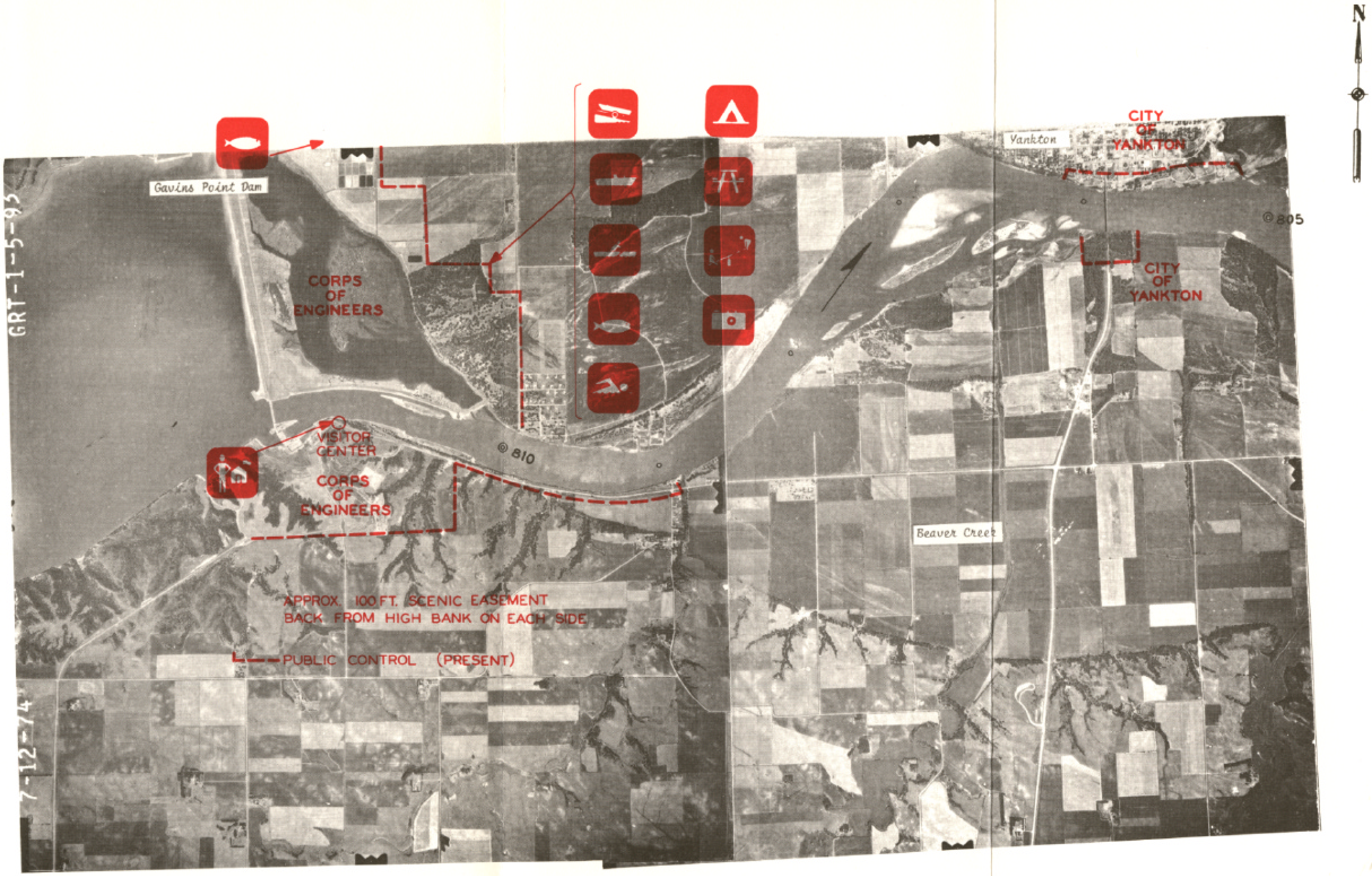
POWER PLANT

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS

FEBRUARY 1977



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GREGORY COUNTY PUMPED STORAGE PROJECT
DISCHARGE CHANNEL
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE 805 TO 811
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.

PLAN OF WILD AND SCENIC RIVER DESIGNATION

RIVER MILE 799 TO 805

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE: 1 INCH = 2000 FEET

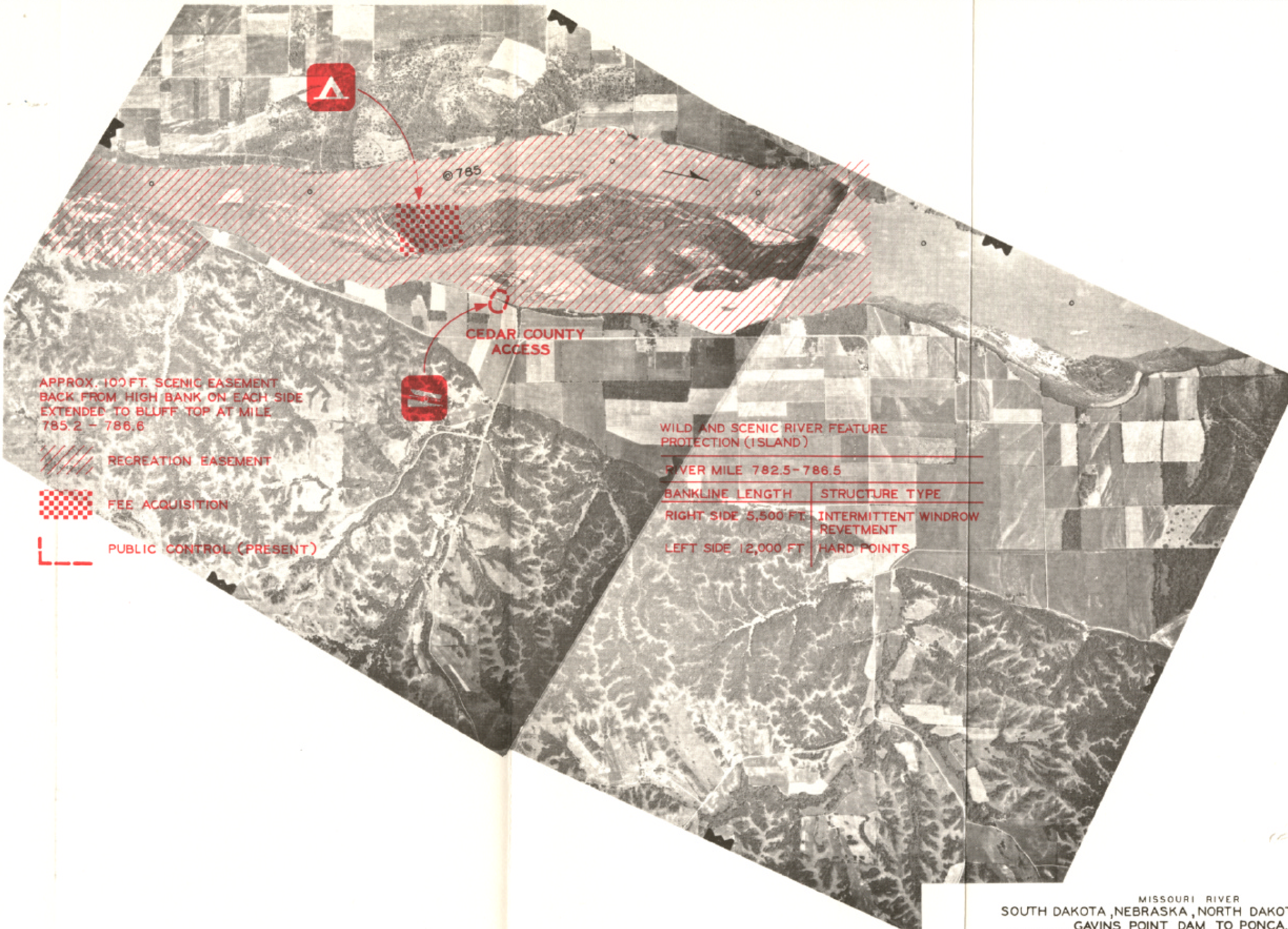
SCALE 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE **795 TO 799**
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE 787 TO 794
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE: 1 INCH = 2000 FEET

APPENDIX I
PLATE E-49



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.

PLAN OF WILD AND SCENIC RIVER DESIGNATION

RIVER MILE 782 TO 787

MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

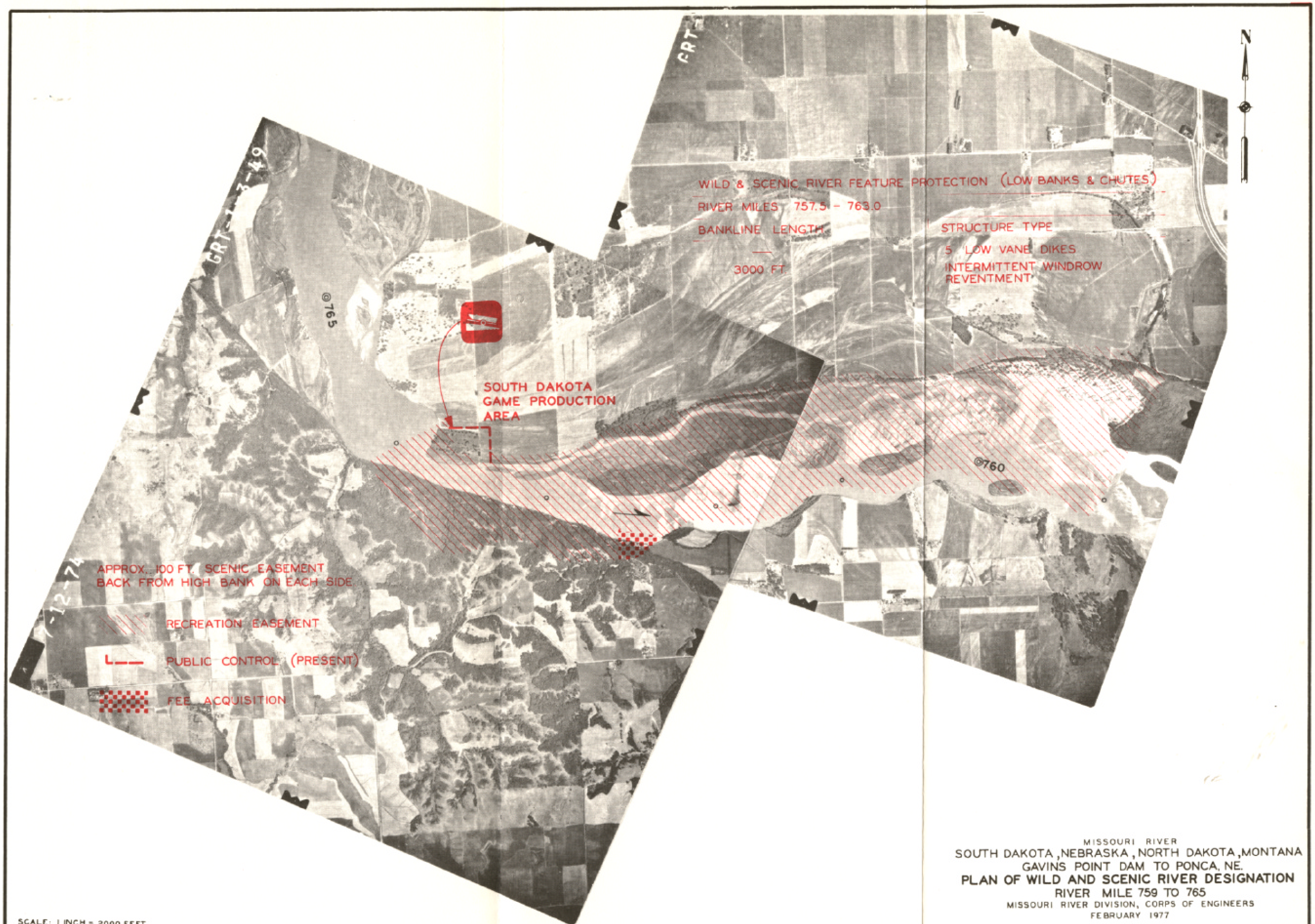
SCALE: 1 INCH = 2000 FEET

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE **772** TO **781**
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-51

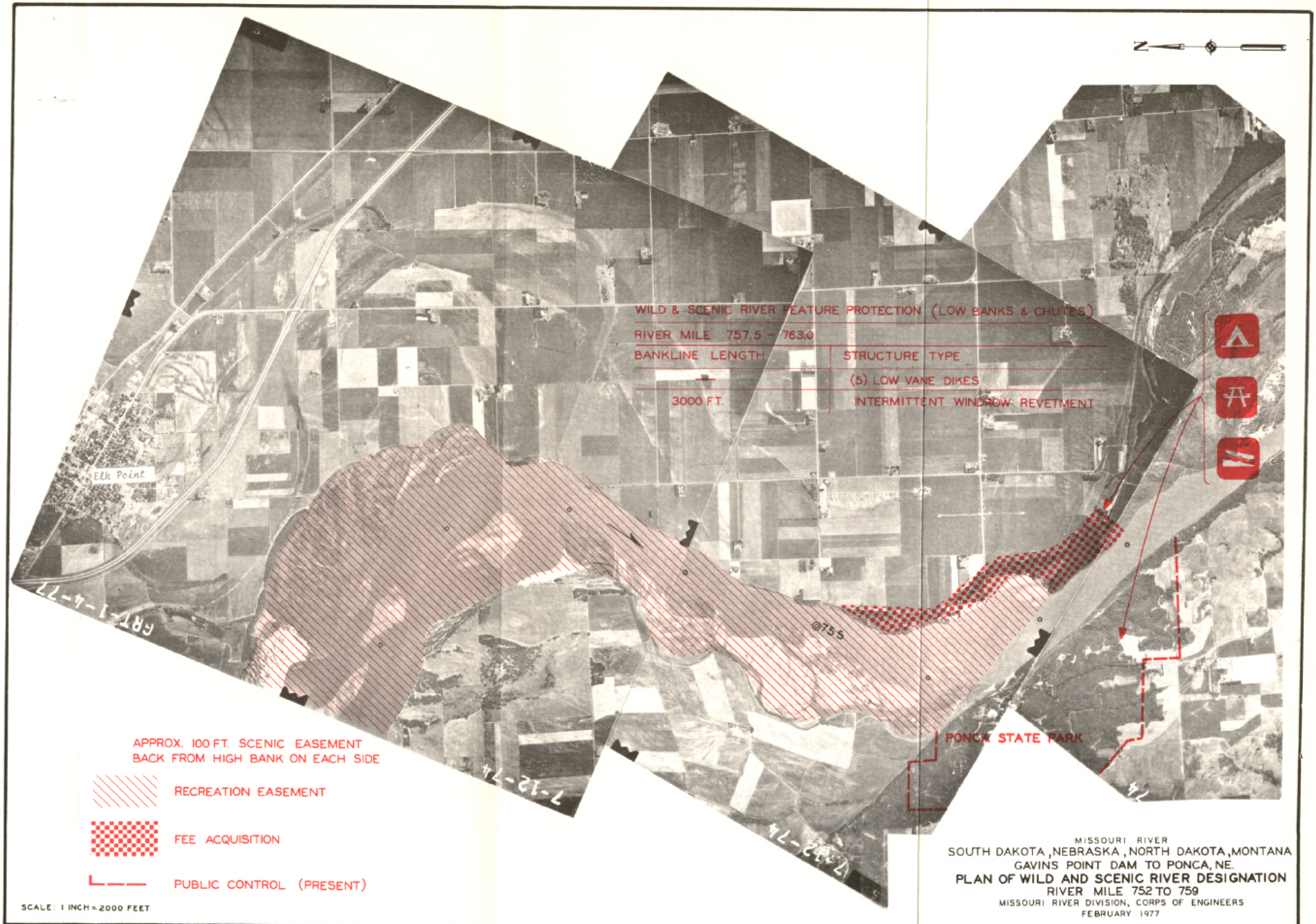
MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE 765 TO 772
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE: 1 INCH = 2000 FEET



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE 759 TO 765
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

SCALE: 1 INCH = 2000 FEET



MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
GAVINS POINT DAM TO PONCA, NE.
PLAN OF WILD AND SCENIC RIVER DESIGNATION
RIVER MILE 752 TO 759
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977

APPENDIX I
PLATE E-54

SECTION F

ECONOMICS OF SELECTED PLAN

ECONOMICS OF SELECTED PLAN

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LIST OF TABLES (Cont'd)

LIST OF TABLES (Cont'd)

SECTION F

ECONOMICS OF SELECTED PLAN

1. This section consolidates and summarizes the economic data for the selected plan with the exception of bank stabilization elements which were presented in Section E. The economic criteria presented in Section D, pages 5-7, provided the basis upon which these data were founded. In all instances, benefits and costs were evaluated on 1976 price levels and an interest rate of 6-3/8 percent. Economic life of 50 years was used except for the Fort Peck and Garrison hydro-power additions which were evaluated on the basis of 100 years.

Hydro-Power

2. The justification of the recommended plan is contingent upon providing average annual benefits greater than average annual charges. The costs and benefits, as well as results of the net NED benefit test, "comparability" test, and financial feasibility test are discussed in the following paragraphs.

Table F-1 - HYDRO-POWER
First Cost Summary
($1,000)

	Total Costs	(Mitigation & Relocation Incl. in Total)
FORT PECK		
Lands and Damages	$ 1,156	(292)
Dams	33,700	
Power Plant	31,800	
Roads	55	(55)
Recreation Areas	200	(200)
Bank Stabilization	350	(350)
Bldg., Ground, Utilities	200	
Perm. Oper. Equipment	100	
Engineering & Design	5,100	(47)
Supervision & Inspection	4,339	(40)
TOTAL	$ 77,000	(984)
GARRISON		
Lands and Damages	1,977	(210)
Dams	25,040	
Power Plant	45,200	
Levee	20	(20)
Recreation Area	25	(25)
Bldg., Grounds, Utilities	200	
Perm. Oper. Equipment	100	
Engineering & Design	5,572	(4)
Supervision & Inspection	4,866	(3)
TOTAL	$ 83,000	(262)
GREGORY COUNTY		
Lands and Damages	1,372	
Dams	113,600	
Power Plant	88,210	
Roads	4,700	
Bldg., Grounds, Utilities	350	
Perm. Oper. Equipment	200	
Engineering & Design	15,300	
Supervision & Inspection	13,268	
TOTAL	$237,000	

Costs

3. Project investment cost is equal to first cost plus interest during construction. Based on the cost of similar projects, a contingency allowance of approximately 15 percent (20 percent for lands), an engineering and design cost, and a supervision and administration cost of approximately eight and seven percent, respectively, have been included in project first cost, summarized in Table F-1. Itemized unit costs and detailed replacement costs are presented in Tables F-7 through F-12 at the conclusion of this subsection. Annual costs as shown in Table F-2 include interest and amortization, operation and maintenance, and major replacement. Operation and maintenance is based on costs of similar projects and includes costs for recreation and stabilization. Energy cost for pump back at the Gregory County pumped-storage site and the value of the recreation loss at Ft. Peck and Garrison is also included as an annual cost.

Table F-2 HYDRO-POWER COST SUMMARY
($1,000)

	Ft. Peck	Garrison	Gregory County	Total System
First Cost	$77,000	$83,000	$237,000	$397,000
Interest During Construction	7,253	7,748	37,553	52,554
Investment Cost	$84,253	$90,748	$274,553	$449,554
(Cost per MW Installed)	(455)	(334)	(233)	
Interest & Amortization	$ 5,382	$ 5,797	$ 18,337	$ 29,516
Operation & Maintenance	160	180	950	1,290
Major Replacement	43	61	77	181
Pumping Energy	-	-	14,580 1/	14,580
Recreation Loss 2/	23	32	-	55
Annual Cost	$ 5,608	$ 6,070	$ 33,944	$ 45,622

1/ 1,080 mw x 1,500 hr x $9/mwh
2/ Value of $2.25 per recreation day

Benefits

4. Benefits consist of two components: power benefits and area redevelopment benefits. Power benefits are based on the cost of providing equivalent power via the most likely alternative means at composite financing. Composite financing, at 9.22 percent interest

rate, has been determined by the Federal Power Commission to approximate the mixture of private, REA, and publicly-owned power generation in the marketing area. At each hydro-power site, at both composite and Federal financing, the least costly and most probable alternative source of power is oil-fired combustion turbine units.

POWER VALUES

5. Power values consist of both a capacity and an energy component. Capacity values are expressed in dollars per kilowatt and are derived from a determination of the fixed costs of the alternative source of supply. Energy values are defined in terms of mills per kilowatt hour and vary primarily with the energy cost of the alternative source. Power values are presented in Table F-3 for both composite and Federal financing.

Table F-3 POWER VALUES

	Capacity (\$/KW)		Energy (Mills/KWH)		Pumping Cost (Mills/KWH)	
	Composite	Federal	Composite	Federal	Composite	Federal
Plan Components Individually						
Ft. Peck	41.80	33.00	9.0 1/	9.0 1/	-	-
Garrison	42.10	33.30	9.0 1/	9.0 1/	-	-
Gregory County	20.50	11.80	25.8	25.8	9.0	9.0
Total System						
Main Stem	41.00	32.30	9.0 1/	9.0 1/	-	-
Gregory County	20.50	11.80	25.8	25.8	9.0	9.0

1/ Value applied to Net Energy Loss

6. The power values displayed are applicable for additional capacity utilized in a fully coordinated system. Costs of strengthening the existing transmission grid have not been included; it is assumed they would be comparable for either additional hydro-power or alternative means of generation. Combustion turbine units are assumed to locate at existing substations on the grid.

POWER BENEFITS

7. The power portion of hydro-power benefits are obtained by applying the power values just discussed to the specific characteristics of a hydro-plant under evaluation. Capacity benefits are computed as the sum of:

Dependable Capacity x Power Capacity Value

Interruptible Capacity (Installed minus Dependable) x 1/2 Power Capacity Value

The additional peaking capacity at the mainstem sites will result in a minor energy loss, since the higher average tailwater is not quite offset by the decline in "spills." The Gregory County pumped storage plant has an energy component which is evaluated as one portion of the project benefits; pump-back energy has already been identified as one portion of the project costs.

8. Power benefits for the selected plan are displayed in Table F-4. The benefits shown are based on simultaneous installation of all hydro-power plan components. Since the power values for installation of each site individually are the same or greater, NED benefits based on simultaneous implementation of the entire recommended system represent a minimum benefit. Any other implementation strategy will yield greater benefits for this selected set of plan components.

Table F-4 ANNUAL POWER BENEFITS (NED)

	Ft. Peck	Garrison	Gregory County	Total System
Capacity				
Dependable KW	196,000	220,000	1,080,000	
Value/KW	$41.00	$41.00	$20.50	
Dep. Benefit	$8,036,000	$9,020,000	$22,140,000	$39,196,000
Interruptible KW	0	52,000	100,000	
Inter. Benefit	0	$1,066,000	$1,025,000	$2,091,000
Energy				
Million KWH	-26.3	-66.3	1080.0	
Value/KWH	$0.009	$0.009	$0.0258	
Benefits	-$236,700	-$596,700	$27,864,000	$27,030,600
Total Ann. Bene.	$7,799,300	$9,489,300	$51,029,000	$68,317,600

REDEVELOPMENT BENEFITS

9. In addition to power benefits, the NED benefits include earnings to unemployed members of the labor force engaged in project construction. The "Area Trends in Employment and Unemployment" published by the U. S. Department of Labor indicates that counties and Indian Reservations adjacent to the proposed power projects have sufficiently high chronic unemployment rates to qualify as redevelopment areas. Omaha District surveys of major construction project work forces indicate that approximately 10 percent of the total employment during each year of project construction is drawn from the pool of the unemployed. Overall, approximately 22 percent of project first cost is labor cost.

REDEVELOPMENT BENEFITS
($1,000)

Ft. Peck	$110
Garrison	115
Gregory County	350
Total System	$575

Comparability Test

10. In addition to providing net NED benefits, the selected plan must pass the "comparability test," which means that the hydro-power costs must be less than the costs of the most likely alternative (oil-fired combustion turbine units) evaluated on the basis of fully comparable financial factors, thereby eliminating the advantage which accrues to Federal projects solely because of a lower interest rate. Comparability benefits are computed by using the same methodology as in the preceding Power Benefits section except the capacity and energy values based on Federal financing from Table F-3 are inserted into the computations. The results of the comparability test, which are shown in Table F-5, reveal that each recommended hydro-power plan element exhibits benefits greater than costs and the plan thereby passes the comparability test.

Table F-5 ANNUAL POWER BENEFITS (AT FEDERAL INTEREST)

	Ft. Peck	Garrison	Gregory County	Total System
Capacity				
Dependable KW	196,000	220,000	1,080,000	
Value/KW	$32.30	$32.30	$11.80	
Dep. Benefit	$6,330,800	$7,106,000	$12,744,000	$26,180,800
Interruptible KW	0	52,000	100,000	
Inter. Benefit	0	$839,800	$590,000	$1,429,800
Energy				
Million KWH	-26.3	-66.3	1080.0	
Value/KWH	$0.009	$0.009	$0.0258	
Benefits	-$236,700	-$596,700	$27,864,000	$27,030,600
Total Ann. Bene.	$6,094,100	$7,349,100	$41,198,000	$54,641,200

Financial Feasibility Test

11. The recommended plan must also achieve financial feasibility. This requires that net revenues, at market, be sufficient to repay power costs, including interest, within a 50-year period. The power marketing agency, the Bureau of Reclamation, has determined the financial feasibility of hydro-power development associated with the Missouri River mainstem system and adjacent pumped storage. The document declaring the selected plan to be financially feasible is included in Appendix 2.

Maximization

12. The sizing of each hydro-power addition such that the excess of benefits over costs is maximized has been accomplished for each site. A detailed discussion of this effort is included in Section D.

Justification

13. The selected hydro-power plan passes all three economic tests resulting in net NED benefits, net comparability benefits, and financial feasibility as stated by the marketing agency. The annual NED costs and benefits for components of the recommended hydro-power plan installed simultaneously are summarized in Table F-6.

Table F-6 ECONOMIC SUMMARY
($1,000)

	Ft. Peck	Garrison	Pumped Storage	Total System
Average Annual Benefits	$7,909	$9,604	$51,379	$68,893
Average Annual Costs	5,608	6,070	33,944	45,622
Net Benefits	2,301	3,534	17,435	23,271
Benefit-Cost Ratio	1.4	1.6	1.5	1.5

Table F-7 FORT PECK
Estimated Construction Cost

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
01	LANDS & DAMAGES				
	Cropland	Acre	$ 450.00	1,770	$ 796,500
	Farm bldgs (2)	L.S.			60,000
	Severence				85,600
	Subtotal				942,100
	Contingencies				188,420
	Acquisition				25,480
	Total Lands & Damages				$1,156,000
04	DAMS				
04.1	Earth Dam - Reregulation				
	Diversion & Care of River				
	Cofferdam				
	Steel Sheet				
	Piling	S.F.	15.50	110,000	1,705,000
	Cell Fill	C.Y.	11.00	37,000	407,000
	Pumping	L.S.			66,000
	Embankment				
	Excavation				
	Stripping	C.Y.	2.10	125,200	262,920
	Embankment -				
	Random	C.Y.	2.25	360,000	810,000
	Slope Treatment				
	Riprap	C.Y.	16.00	40,720	651,520
	Gravel bedding	C.Y.	10.00	16,400	164,000
	Road Surfacing	L.S.			26,000
	Cut-off Trench	C.Y.	2.80	86,000	240,800
	Reregulating Structure				
	Excavation structure	C.Y.	2.10	13,900	29,190
	Concrete	C.Y.	120.00	16,000	1,920,000
	Gates (6)	Tons	2,600.00	310	806,000
	Hoist (6)	Each	46,000.00	6	276,000
	Sheet Pile Cutoff	S.F.	15.50	20,400	316,200
	Associated Items				
	Electric Power	L.S.			103,000
	Gate Heating	L.F.	13.00	500	6,500
	Subtotal				7,790,130
	Contingencies				1,209,870
	Total Reregulation Structure				$9,000,000

Table F-7 - Continued

ACCT	ITEMS	UNIT	UNIT COST	QUANTITY	COST
04.4	Power Intakes				
	Intake gates & guides	Lb.	$ 2.10	960,000	$ 2,016,000
	Intake gates & hoists	Each	105,000	4	420,000
	Remove exist. gates	L.S.			55,000
	Remodel Intake passage	L.S.			830,000
	Portal excav.	C.Y.	5.00	2,000	10,000
	Concrete Removal	C.Y.	35.00	400	14,000
	Concrete floor	C.Y.	120.00	400	48,000
	Steel liner	Ton	1,300.00	9,800	12,740,000
	Steel penstock	Ton	1,300.00	900	1,170,000
	Liner backfill	C.Y.	129.00	24,000	3,096,000
	Penstock enclosure roof	Ton	1,100.00	550	605,000
	Penstock slab roof	C.Y.	135.00	2,000	270,000
	Roof Membrane	S.F.	.70	55,000	38,500
	Roof fill	C.Y.	10.00	3,000	30,000
	Reinforcement	Lb.	.50	264,000	132,000
	Subtotal				21,474,500
	Contingencies				3,225,500
	Total Power Intakes				$24,700,000
	Total Dams				$33,700,000
07	POWERPLANT				
07.1	Powerhouse				
	Diversion & Care of River				
	Unwatering				
	Steel Sheet Piling	S.F.	15.50	20,000	310,000
	Fill Cells	C.Y.	11.00	3,700	40,700
	Pumping	L.S.			400,000
	Powerhouse Structure				
	Excavation	C.Y.	4.20	24,500	102,900
	Concrete Removal	C.Y.	35.00	1,730	60,550
	Concrete				
	Substructure	C.Y.	120.00	36,200	4,344,000
	Superstructure	C.Y.	135.00	5,200	702,000
	Reinforcement	Lb.	.50	3,520,000	1,760,000
	Structural Steel	Ton	1,100.00	250	275,000
	Miscellaneous Metal	Lb.	1.70	100,000	170,000
	Arch. Struct. - Bldg.	L.S.			400,000

Table F-7 - Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
07.1	Powerhouse (cont'd)				
	Mechanical				
	Unwatering & Drainage	L.S.			$ 198,000
	Heat., Vent., & A.C.	L.S.			130,000
	Water Systems	L.S.			30,000
	Elect. Lighting	L.S.			203,000
	Site Work	L.S.			35,000
	Draft Tube Equipment				
	Draft Tube Gantry	Each		1-17 ton	130,000
	Draft Tube Gates	Lb.	$ 2.10	90,000	189,000
	Draft Tube Gate Guides	Lb.	2.00	90,000	180,000
	Subtotal				9,660,150
	Contingencies				1,439,850
	Total Powerhouse				$11,100,000
07.2	Turbines & Generators				
	Turbine & Governor 128,000 HP	Each	3,250,000	2	6,500,000
	Generator 92,500 KW	Each	3,200,000	2	6,400,000
	Subtotal				12,900,000
	Contingencies				2,000,000
	Total Turbines & Governors				$14,900,000
07.3	Switchyard, Accessory Equipment, & Tailrace				
	Switchyard, Accessory & Misc. Power Plant Equipment				
	Switchyard				
	Line Bay	Each		1	340,000
	Transfer Bay	Each		1	340,000
	Transformer Bay	Each	231,000.00	3	693,000
	Transformers	Each	385,000.00	2	770,000
	15 kv Bus, 400 Amp	L.F.	500.00	320	160,000

Table F-7 - Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
07.3	Switchyard, Accessory Equipment & Tailrace (cont'd)				
	Switchyard, Accessory & Misc. Power Plant Equipment (cont'd)				
	Mechanical Items				
	CO_2 Equipment	L.S.			$ 33,000
	Compressed Air	L.S.			25,000
	PH Bridge Crane	L.S.			750,000
	Electrical Items				
	Control Switchboards	L.S.			65,000
	13.8 Switchgear	L.S.			177,000
	480V Sta. Serv.	L.S.			95,000
	Supervisory Equipment	L.S.			82,000
	Conduit & Cable	L.S.			170,000
	D.C. System	L.S.			44,000
	Subtotal				3,744,000
	Contingencies				556,000
	Total Switchyard				$ 4,300,000
07.34	Tailrace				
	Excavation	C.Y.	$ 4.20	22,400	94,080
	Concrete Removal	C.Y.	35.00	3,900	136,500
	Tailrace Walls, Slabs				
	Concrete				
	Wall	C.Y.	125.00	2,560	320,000
	Slab	C.Y.	120.00	3,910	469,200
	Reinf.	Lb.	.50	440,000	220,000
	Anchors	L.F.	7.00	7,900	55,300
	Subtotal				1,295,080
	Contingencies				204,920
	Total Tailrace				$ 1,500,000
	Total Powerplant				$31,800,000
08	ROADS				
	Excavation & Embankment				
	Embankment	C.Y.	1.00	6,200	6,200
	Drainage				
	Reinforced 4x4 Box Culvert	L.S.			25,000
	Slide Gate & Miscellaneous	L.S.			15,000
	Subtotal				46,200
	Contingencies				8,800
	Total Roads				$ 55,000

Table F-7 - Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY		COST
14	RECREATION AREAS					
	(Dredge Cut, Reregulation					
	Dam Site)					
	Access Roads	Each	$20,000.00	2	$	40,000
	Activity Guides					
	& Controls					
	Boat Ramp	Each	30,000.00	2		60,000
	Dock	Each	5,000.00	2		10,000
	Parking Area	Car/				
	(Dredge Cut)	Trailer	300.00	25		7,500
	Parking Area	Car/				
	(Dam Site)	Trailer	300.00	60		18,000
	Vault Toilet	Each	7,000.00	2		14,000
	Misc.					20,000
	Subtotal					169,500
	Contingencies					30,500
	Total Recreation Area				$	200,000
16	BANK STABILIZATION					
	Revetment, Composite					
	(Scout Island)	L.F.	90.00	2,400		216,000
	Revetment, Composite					
	(Duck Island)	L.F.	90.00	1,000		90,000
	Subtotal					306,000
	Contingencies					44,000
	Total Bank Stabilization				$	350,000
19	BLDGS, GROUNDS &					
	UTILITIES	L.S.				175,000
	Contingencies					25,000
	Total Bldgs, Grounds & Utilities				$	200,000
20	PERM. OPER. EQUIPMENT	L.S.				85,000
	Contingencies					15,000
	Total Perm. Oper. Equipment				$	100,000
30	ENGINEERING & DESIGN					5,100,000
31	SUPERVISION & INSPECTION					4,339,000
			Total First Cost			$77,000,000

Table F-8 GARRISON
Estimated Construction Cost

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
01	LANDS & DAMAGES				
	Lands		$ 570.00	2,575	$ 1,467,750
	Severence				146,790
	Subtotal				1,614,540
	Contingencies				322,950
	Acquisition				39,510
	Total Lands & Damages				$ 1,977,000
04	DAMS				
04.1	Earth Dam - Reregulation				
	Diversion & Care of the River				
	Cofferdam				
	Steel Sheet Piling	S.F.	160,000	15.50	2,480,000
	Cellular Cell Fill	C.Y.	55,000	11.00	605,000
	Pumping	L.S.			50,000
	Embankment				
	Excavation Stripping	C.Y.	93,000	2.10	195,300
	Embankment Fill				
	Random	C.Y.	390,300	2.25	878,180
	Embankment Slope Treatment				
	Riprap	C.Y.	72,900	16.00	1,166,400
	Gravel Bedding	C.Y.	26,600	10.00	266,000
	Road Surfacing	L.S.			19,000
	Cut-off Trench	C.Y.	33,300	2.80	93,240
	Reregulating Structure (12 gates)				
	Excavation	C.Y.	29,100	2.10	61,110
	Concrete	C.Y.	33,000	120.00	3,960,000
	Gates	Tons	625	2,600.00	1,625,000
	Hoist	Each	12	46,000.00	552,000
	Sheet Pile Cut off	S.F.	32,000	15.50	496,000
	Associated Items				
	Electric Power	L.S.			80,000
	Gate Heating	L.S.	1,100	13.00	14,300
	Subtotal				12,541,530
	Contingencies				1,958,470
	Total Reregulating Structure				$14,500,000

Table F-8 Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
04.4	Power Intake Works				
	Trash Racks & Guides	L.S.			$ 600,000
	Tunnel Concrete liner	C.Y.	$ 73.00	9,600	700,800
	Steel liner	Ton	1,300.00	4,220	5,486,000
	Steel Penstock	Ton	1,300.00	1,230	1,599,000
	Penstock Concrete	C.Y.	130.00	400	52,000
	Penstock Inclosure	Ton	1,100.00	400	440,000
	Roof Deck	S.F.	4.00	72,500	290,000
	Subtotal				9,167,800
	Contingencies				1,372,200
	Total Power Intakes				$10,540,000
	Total Dams				$25,040,000
07	POWERPLANT				
07.1	Powerhouse				
	Diversion & Care of River				
	Cofferdam				
	Steel Sheet Piling	S.F.	15.50	54,900	850,950
	Fill Cells	C.Y.	11.00	17,600	193,600
	Pumping	L.S.			345,000
	Powerhouse Structure				
	Concrete Removal	C.Y.	35.00	23,130	809,550
	Concrete				
	Substructure	C.Y.	120.00	73,550	8,826,000
	Superstructure	C.Y.	135.00	6,500	877,500
	Slab	C.Y.	67.00	3,200	214,400
	Reinforcement	Lb.	.50	6,856,500	3,428,250
	Structural Steel	Ton	1,100.00	140	154,000
	Misc. Metal	Lb.	1.70	140,000	238,000
	Arch. Struct. - Bldg.	L.S.			250,000
	Mechanical				
	Unwatering & Sta. Drainage	L.S.			160,000
	Heat.Vent. & A.C.	L.S.			129,000
	Water System	L.S.			18,000
	Electrical Lighting	L.S.			200,000
	Site Work	L.S.			30,000
	Draft Tube Gate Guides	Lb.	2.00	134,000	268,000
	Subtotal				16,992,250
	Contingencies				2,707,750
	Total Powerhouse				$19,700,000

Table F-8 Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
07.2	Turbines & Generators				
	Turbines & Governors				
	110,000 HP	Each	$3,015,000	2	$ 6,030,000
	155,000 HP	Each	4,025,000	1	4,025,000
	Generator				
	80,000 kW	Each	2,415,000	2	4,830,000
	112,000 kW	Each	3,520,000	1	3,520,000
	Subtotal				18,405,000
	Contingencies				2,995,000
	Total Turbines & Generators				$21,400,000
07.3	Switchyard, Accessory Equipment & Tailrace				
	Switchyard Accessory and Misc. Power Plant Equip.				
	Switchyard				
	Linebay	Each		1	325,000
	Transfer Bay	Each		1	225,000
	Transformers				
	32,500 KVA	Each	140,000	6	840,000
	45,200 KVA	Each	200,000	3	600,000
	Oil Pipe Cable	Ft.	175	2,000	350,000
	Mechanical Items				
	CO_2 Equipment	L.S.			45,000
	Compressed Air	L.S.			8,000
	Electrical Items				
	Control Switch-board	L.S.			55,000
	15 kV Switchgear	L.S.			400,000
	480V Sta. Ser.	L.S.			200,000
	Supervisory Equipment	L.S.			105,000
	Conduit & Cable	L.S.			310,000
	D.C. Systems	L.S.			35,000
	Subtotal				3,498,000
	Contingencies				602,000
	Total Switchyard				$ 4,100,000
	Total Powerplant				$45,200,000

Table F-8 Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
11	LEVEE				
	Embankment	C.Y.	$ 1.50	7,100	$ 10,650
	CMP w/flap	L.S.			2,000
	Seeding	Acre	400.00	8	3,200
	Subtotal				15,850
	Contingencies				4,150
	Total Levee				$ 20,000
14	RECREATIONAL AREAS				
	Boat Ramp	L.S.			20,000
	Contingencies				5,000
	Total Recreation				$ 25,000
19	BLDG, GROUNDS & UTILITIES	L.S.			$ 175,000
	Contingencies				25,000
	Total Bldg, Grounds & Utilities				$ 200,000
20	PERM. OPER. EQUIP	L.S.			85,000
	Contingencies				15,000
	Total Remov Oper. Equip.				$ 100,000
30	ENGINEERING & DESIGN				5,572,000
31	SUPERVISION & INSPECTION				4,866,000
	Total First Cost				$83,000,000

Table F-9 GREGORY COUNTY
PUMPED STORAGE
Estimated Construction Cost

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
01	LANDS & DAMAGES				
	Lands	Acre	$ 500.00	1,650	$ 825,000
	Farmhouses & Bldgs.	L.S.	-	-	201,000
	Severence				102,000
	Subtotal				1,128,000
	Contingencies				220,000
	Acquisition				24,000
	Total Lands & Damages				$ 1,372,000
04	DAMS				
04.11	Non-overflow				
	Borrow from tailrace	C.Y.	1.30	6.6×10^6	8,580,000
	Borrow from forebay	C.Y.	1.30	3.05×10^6	3,965,000
	Pervious Drains	C.Y.	7.50	1.186×10^6	8,895,000
	Riprap & Spalls	Ton	14.00	710,000	9,940,000
	Subtotal				31,380,000
	Contingencies				4,720,000
	Total Non-overflow				$36,100,000
04.4	Power Structures				
	Forebay Imperv. liner	C.Y.	1.40	5.59×10^6	7,826,000
	Intake struct. & shaft	L.S.	-	-	7,280,000
	Main tunnel & liner	L.S.	-	-	45,683,000
	Branch tunnel & liner	L.S.	-	-	1,310,000
	Slope & tunnel drain	L.S.	-	-	1,300,000
	Butterfly Valves	L.S.	-	-	4,020,000
	Subtotal				67,419,000
	Contingencies				10,081,000
	Total Power Structures				$77,500,000
	Total Dams				$113,600,000
07	POWERPLANT				
07.1	Powerhouse				
	Substructure	L.S.	-	-	5,420,000
	Superstructure	L.S.	-	-	14,586,000
	Subtotal				20,006,000
	Contingencies				3,004,000
	Total Powerhouse				$23,010,000

Table F-9 Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
07.2	Turbines & Generators	L.S.	-	-	$36,900,000
	Contingencies				5,500,000
	Total Turbines & Generators				$42,400,000
07.3	Switchyard, Accessory Equip. Tailrace switchyard & misc. Powerplant Equip.				
	Switchgear	L.S.	-	-	1,698,000
	Main transformer	L.S.	-	-	2,950,000
	Governors	L.S.	-	-	808,000
	Mech. Equip.	L.S.	-	-	1,394,000
	Misc. Elec. Equip.	L.S.	-	-	2,098,000
	SwitchydStruct.&Equip	L.S.	-	-	527,000
	Elec.Equip.Install.	L.S.	-	-	2,525,000
	Subtotal				$12,000,000
	Contingencies				1,800,000
	Total Switchyard, Access. Equip.				$13,800,000
07.34	Tailrace				
	Exc. not charged toForebay	C.Y.	$0.45	12×10^6	5,400,000
	Riprap in transition	Ton	14.00	4,940	69,160
	Tailrace Paving	C.Y.	70.00	930	65,100
	Retaining Wall	L.S.	-	-	2,020,000
	Subtotal				7,554,260
	Contingencies				1,445,740
	Total Tailrace				$ 9,000,000
	Total Powerplant				$88,210,000
08	ROADS				
	Access Road	L.S.			1,200,000
	Project Roads	L.S.			2,600,000
	Misc.	L.S.			250,000
	Subtotal				4,050,000
	Contingencies				650,000
	Total Roads				$ 4,700,000
19	BLDGS, GROUNDS & UTILITIES	L.S.			300,000
	Contingencies				50,000
	Total Bldgs, Grounds & Utilities				$ 350,000

Table F-9 Continued

ACCT	ITEM	UNIT	UNIT COST	QUANTITY	COST
20	PERM. OPER. EQUIPMENT	L.S.			$ 175,000
	Contingencies				25,000
	Total Perm. Oper. Equip.				200,000
30	ENGINEERING & DESIGN				15,300,000
31	SUPERVISION & INSPECTION				13,268,000
		Total First Cost			$237,000,000

Table F-10 - REPLACEMENT COSTS
FORT PECK

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Trash Racks	2	40 years	$ 500,000
Turbine Runners	2 - 92.5 MW	40 years	900,000
Governors:			
Oil Pumps	2	40 years	75,000
Ball Head	2	40 years	10,000
Permanent Magnet Generator	2	40 years	25,000
Air Compressors	2	25 years	25,000
Generators:			
Stator Windings	2 - 92.5 MW	35 years	1,280,000
Thrust Bearings	2 - 92.5 MW	35 years	512,000
Rotor Windings	2 - 92.5 MW	50 years	640,000
Switchyard			
Line Bay			
Oil Circuit Brkr.	1	40 years	50,000
Motor Oper. Discon.	1	40 years	3,500
Discon. Switches	3	40 years	7,500
Coup. Cap. Pot. Dev.	3	35 years	15,000
Carrier Current Line Trap	1	35 years	3,000
Cable	L.S.	35 years	8,000
Total			$ 88,000
Transfer Bay			
Oil Circuit Brkr.	1	40 years	$ 50,000
Discon. Switches	2	40 years	5,000
Cable	L.S.	35 years	3,000
Total			$ 58,000
Transformer Bay 1 & 2			
Oil Circuit Brkr.	2	40 years	$ 50,000
Motor Oper. Discon.	2	40 years	7,000
Discon. Switches	4	40 years	10,000
Cable	L.S.	35 years	8,000
Total			$ 75,000

Table F-10 - CONTINUED

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Transformers			
110 MVA 3Ø			
(windings)	2	35 years	$ 383,274
Control Switchboards	L.S.	35 years	61,214
13.8 kV Switchgear	L.S.	40 years	176,838
480-volt Sta. Ser.	L.S.	35 years	95,219
Supervisory Equip.	L.S.	15 years	81,619
Conduit & Cable			
(Control Cable			
System)	L.S.	35 years	50,000
D.C. System	L.S.	35 years	10,000
Roads			
Reinforced 4 x 4			
Box Culvert	L.S.	50 years	24,300
Slide Gate	L.S.	25 years	15.000
Recreation Areas			
Access Roads	2	30 years	40,000
Dock	2	35 years	10,000
Parking	2	30 years	22,950
Vault Toilet	2	25 years	14,000
Boat Ramp	2	35 years	60,000
Reregulation Gates	6	40 years	806,000

Table F-11 - REPLACEMENT COSTS
GARRISON

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Trash Racks	3	40 years	$600,000
Turbine Runners	2 - 80 MW	40 years	860,000
	1 - 112 MW		574,000
Governors:			
Oil Pumps	3	40 years	90,000
Ball Head	3	40 years	12,000
Permanent Magnet Generator	3	40 years	30,000
Air Compressors	3	25 years	30,000
Generators:			
Stator Windings	2 - 80 MW	35 years	966,000
	1 - 112 MW		705,000
Thrust Bearings	2 - 80 MW	35 years	386,000
	1 - 112 MW		282,000
Rotor Windings	2 - 80 MW	50 years	483,000
	1 - 112 MW		352,000
Switchyard			
Line Bay			
Oil Circuit Brkr.	2	40 years	100,000
Discon. Switches	4	40 years	10,000
Coup. Cap. Pot. Dev.	3	35 years	15,000
Carrier Current Line Trap	1	35 years	3,000
Cable	L.S.	35 years	8,000
Total			$136,000
Transfer Bay			
Oil Circuit Brkr.	1	40 years	50,000
Discon. Switches	2	40 years	5,000
Motor Oper. Discon.	1	40 years	3,500
Total			$ 58,500

Table F-11 - CONTINUED

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Transformers			
32,500 kVA - 1Ø	6	35 years	$415,012
45,200 kVA - 1Ø (windings)	3	35 years	288,535
Control Switchboards	L.S.	35 years	53,667
15 kV Switchgear	L.S.	35 years	370,342
480-volt Sta. Ser. Switchgear	L.S.	35 years	178,879
Supervisory Equip.	L.S.	15 years	102,208
Conduit & Cable (Control Cable System)	L.S.	35 years	50,000
D.C. System	L.S.	35 years	10,000
Corr. Metal Pipe w/flap	L.S.	25 years	2,000
Boat Ramp	L.S.	35 years	20,000
Reregulation Gates	L.S.	40 years	1,625,000

Table F-12 - REPLACEMENT COSTS
GREGORY COUNTY PUMPED-STORAGE PLANT

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Trash Racks	3	40 years	$ 202,000
Turbine Runners	3 - 394 MW	40 years	2,000,000
Governors:			
Oil Pumps	3	40 years	121,300
Ball Head	3	40 years	16,160
Permanent Magnet Generator	3	40 years	40,400
Air Compressors	3	25 years	40,400
Generators:			
Stator Windings	3 - 394 MW	35 years	2,665,000
Thrust Bearings	3 - 394 MW	35 years	1,068,000
Rotor Windings	3 - 394 MW	50 years	1,332,000
Switchyard:			
Line Bay			
Oil Circuit Brkr.	4	40 years	306,100
Discon. Switches	8	40 years	119,840
Coup. Cap. Pot. Dev.	2	35 years	25,680
Carrier Current Line Trap	2	35 years	6,000
Cable	L.S.	35 years	8,000
Total			$ 465,620
Transfer Bay			
Oil Circuit Brkr.	3	40 years	229,575
Discon. Switches	6	40 years	89,880
Motor Oper. Discon.	3	40 years	51,360
Cable	L.S.	35 years	3,000
Total			$ 373,815
Instrument Transformers			
Potential Trans.	3	45 years	22,470
Current Trans	6	45 years	51,360
Total			$ 73,830
Transformers			
159,000 kVA 1Ø (winding)	9	35 years	1,474,875

Table F-12 - CONTINUED

Item	Quantity	Service Life	Total Replacement Costs - July 1976
Control Switchboards	L.S.	35 years	$ 187,250
Engine-Generator	1	40 years	69,550
34.4 kV Switchgear	L.S.	40 years	1,441,930
Sta. Service Equip.	L.S.	35 years	142,890
Cable	L.S.	35 years	68,000
Misc. Service Equip.	L.S.	35 years	60,990
Static Motor Starter	1	35 years	810,000

On-site Rearing Ponds

14. Economic justification of the recommended plan for construction and operation of 12 rearing ponds depends on providing average annual benefits (as measured by increased visitation at Lake Oahe and Lake Francis Case) that exceed average annual charges. Costs and benefits, as well as results of the net NED benefits test are discussed in the following paragraphs.

Costs

15. First costs for enhancement of sports fish resources are cost-shared on a 75 percent-25 percent basis with non-Federal interests under the provisions of PL 89-72 as modified by PL 93-251. Annual costs include interest and amortization, operation, maintenance, and replacement. PL 89-72 provides that a non-Federal sponsor assume all of the last three mentioned annual costs. This project has no interest during construction, even though establishment of the forage beds will be spread over a five-year period, because benefits to the project will accrue during this period. Consequently, investment cost is the same as first cost. Based on costs of similar projects, a contingency allowance of 20 percent, an engineering and design cost of eight percent, and supervision and inspection costs of seven percent have been included in the project first cost. Table F-13 contains a summary of investment and annual cost components. Detailed unit costs and itemized costs are presented in Tables F-15 through F-28 at the conclusion of this subsection covering the seven sites at Lake Oahe and the five sites at Lake Francis Case.

Benefits

16. Benefits are based on the re-establishment of a trophy northern

Table F-13 REARING PONDS COST SUMMARY

Item	Description		
06	FISH AND WILDLIFE		
	Ponds	$999,360	$4,053,900[1/]
	Misc. Mechanical Equip.	45,600	
	Control Structures	266,100	
	Aux. Fish Support Items	2,552,400	
	Fish Hatchery	153,000	
	Structures	14,400	
	Roads	23,040	
30	ENGINEERING AND DESIGN		115,300
31	SUPERVISION AND INSPECTION		100,900
	FIRST COST		4,270,100
	INVESTMENT COST		4,270,100
	Federal @ 75%	3,202,600	
	Non-Federal @ 25%	1,067,500	
	ANNUAL CHARGES		
	FEDERAL		
	Interest @ 6-3/8%		204,200
	Amortization		9,700
	Total Federal Annual Cost		$ 213,900
	NON-FEDERAL		
	Interest @ 6-3/8%		68,100
	Amortization		3,200
	Operation and Maintenance		63,400
	Egg Collection	5,800	
	Rearing Ponds, preparation	43,200	
	Pumps	2,100	
	Mobile Lab. & Rearing Ponds	9,700	
	Mobile Lab. Hauling	2,600	
	Major Replacements		14,700
	Pumps, trailer mounted	14,200	
	Mobile Home - Office	500	
	Total Non-Federal Annual Cost		149,400
	TOTAL PROJECT ANNUAL COST		$ 363,300

[1/] Computation of Engineering and Design and Supervision and Inspection only on Ponds, Fish Hatchery, Control Structures, and Roads. See Detailed Cost Estimate tables.

pike fishery in Oahe and Francis Case lakes. During and for a short time after the filling of these lakes, each developed an outstanding northern pike fishery attracting at least 172,000 people from outside the local area annually. Northern pike populations decreased rapidly after the lakes were completely filled, and are insignificant at present.

17. As the quality of pike fishing declined, total visitation from beyond 100 miles decreased dramatically. At Lake Oahe, total "beyond-100-miles" visitation dropped from 251,000 in 1965 to an estimated 63,000 in 1975. Total visitation, however, nearly quadrupled in the same period. The change at Lake Francis Case was less spectacular, but similar. Visitation in 1965 from beyond 100 miles was 71,600, dropping to 40,300 in 1975. Overall visitation increased 44 percent in the same period.

18. There is virtually no doubt that the decrease in regional and non-resident visitation is due to decline in fishing quality. To establish a conservative estimate of this loss, 1975 visitation from beyond 100 miles was subtracted from that of 1965, and 25 percent of the remainder assignable to Lake Oahe was deducted as probably not fishing for Northern Pike. It is concluded that at least 172,000 fishermen (activity days) were motivated to travel more than 100 miles for pike fishing, and would do it again for the same reason if pike were available.

19. An examination of OBERS-E population projections for South Dakota, and 1962 and 1972 studies entitled The Economic Impact of Sport Fishing in South Dakota indicate an average annual increase in resident fishing license sales of one percent. On this basis, 137,340 resident licenses will be sold in 1980. The 1962 study estimates about 13 percent of these license holders would prefer northern pike fishing. If each would be willing to make a special trip to Lake Oahe or Lake Francis Case every other year for an opportunity

to catch trophy pike, an additional 8,000 pike fishermen would be attracted to these lakes annually. The estimated 172,000 fishermen plus 8,000 amounts to approximately 180,000 new fishing days expected with the proposed project.

20. A $6.00 value per recreation day for this specialized activity was selected on the basis that northern pike and muskellunge as reported in ORRRC Study Report 7 to be the most desired sport fishes in many midwest and northern states (regional interest). The same study identifies the northern pike as a trophy fish preferred by sport fishermen because it attains large individual size and readily strikes a lure. That they are fine table fare is another attribute. An additional contribution to the value of this activity lies in the fact that South Dakota is one of few midwest and northern states that permit taking this species by "dark house spearing." Northern pike remain active in the winter and are quite attracted to live as well as artificial decoys used in this kind of fishing. Dark house spearing, particularly for large northern pike, is a very unique experience. Using a benefit value of $6.00 per recreation day, and an increase of 180,000 days, annual benefits are $1,080,000. Since these benefits are sufficient to justify the selected plan on a present basis, no consideration was given to projected increase in use due to population growth or disposable income nor to improved transportation facilities.

Justification

21. The estimated annual costs, the estimated annual benefits, and the ratio of benefits to costs are summarized in Table F-14.

Table F-14 ECONOMIC ANALYSIS
ON-SITE FISH REARING PONDS

Average Annual Benefits	$1,080,000
Average Annual Costs	363,300
Benefit/Cost Ratio	3.0 to 1.0

Table F-15 FISH REARING PONDS, DETAILED COST ESTIMATE
ITEMS SHARED BY ALL OAHE AREAS

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE				
	MISC. MECH. EQUIP.				
	Pumps				
	Trailer Mtd.1/	Ea.	$ 9,500	2	$ 19,000
	Contingencies				3,800
	AUXILIARY FISH SUPPORT ITEMS				
	Mobile Labs.1/	Ea.	81,000	2	162,000
	Contingencies				32,400
	STRUCTURES				
	Mobile Home-Office1/	Ea.	6,000	1	6,000
	Contingencies				1,200
	TOTAL COST MOBILE EQUIPMENT				$224,400

1/Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-16 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

CHEYENNE RIVER AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	100	3,300
	Subtotal				8,300
	Contingencies				1,660
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	50	200
	Contingencies				40
	TOTAL COST SITE DEVELOPMENT				$293,880

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-17 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

COW CREEK AREA

Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06 FISH AND WILDLIFE PONDS				
Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
Excavation, General	C.Y.	1.50	23,090	34,600
Slope Treatment				
Cutoff Trench	C.Y.	3.00	6,200	18,600
Surfacing	C.Y.	8.00	69	600
Seeding	Ac.	400.00	1.8	700
Subtotal				69,400
Contingencies				13,880
FISH HATCHERY				
Waste Storage Vault	Job	L.S.	1	1,500
Electrical	Job	L.S.	1	10,000
Subtotal				11,500
Contingencies				2,300
CONTROL STRUCTURES				
Sluice Gate	Job	L.S.	1	5,000
Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	100	3,300
Subtotal				8,300
Contingencies				1,660
AUXILIARY FISH SUPPORT ITEMS				
Habitat Improvement[1/]				
Sprigging	Ac.	1,200.00	100	120,000
Seeding - 5 years	Job	L.S.	1	37,000
Subtotal				157,000
Contingencies				31,400
08 ROADS				
Roadway	L.F.	4.00	100	400
Contingencies				80
TOTAL COST SITE DEVELOPMENT				$295,920

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-18 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

WHITLOCK BAY AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	150	4,950
	Subtotal				9,950
	Contingencies				1,990
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	150	600
	Contingencies				120
	TOTAL COST SITE DEVELOPMENT				$296,340

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-19 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

SWAN CREEK AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Waste Storage Vault	Job	L.S.	1	1,500
	Electrical	Job	L.S.	1	10,000
	Subtotal				11,500
	Contingencies				2,300
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	650	21,450
	Subtotal				26,450
	Contingencies				5,290
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	50	200
	Contingencies				40
	TOTAL COST SITE DEVELOPMENT				$317,460

1/ Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-20 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

BLUE BLANKET AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	600	19,800
	Subtotal				24,800
	Contingencies				4,960
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	300	1,200
	Contingencies				240
	TOTAL COST SITE DEVELOPMENT				$314,880

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-21 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

INDIAN CREEK AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Waste Storage Vault	Job	L.S.	1	1,500
	Electrical	Job	L.S.	1	10,000
	Subtotal				11,500
	Contingencies				2,300
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	300	9,900
	Subtotal				14,900
	Contingencies				2,980
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	1,800	7,200
	Contingencies				1,440
	TOTAL COST SITE DEVELOPMENT				$312,000

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-22 - FISH REARING PONDS, DETAILED COST ESTIMATE, OAHE

POLLOCK AREA

Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06 FISH AND WILDLIFE PONDS				
Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
Excavation, General	C.Y.	1.50	23,090	34,600
Slope Treatment				
Cutoff Trench	C.Y.	3.00	6,200	18,600
Surfacing	C.Y.	8.00	69	600
Seeding	Ac.	400.00	1.8	700
Subtotal				69,400
Contingencies				13,880
FISH HATCHERY				
Electrical	Job	L.S.	1	10,000
Contingencies				2,000
CONTROL STRUCTURES				
Sluice Gate	Job	L.S.	1	5,000
Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	650	21,450
Subtotal				26,450
Contingencies				5,290
AUXILIARY FISH SUPPORT ITEMS				
Habitat Improvement[1/]				
Sprigging	Ac.	1,200.00	100	120,000
Seeding - 5 years	Job	L.S.	1	37,000
Subtotal				157,000
Contingencies				31,400
08 ROADS				
Roadway	L.F.	4.00	1,800	7,200
Contingencies				1,440
TOTAL COST SITE DEVELOPMENT				$324,060

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-23 - FISH REARING PONDS, DETAILED COST ESTIMATE

ITEMS SHARED BY ALL LAKE FRANCIS CASE AREAS

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE MISCELLANEOUS MECHANICAL EQUIPMENT				
	Pumps, Trailer Mtd.1/	Ea.	$ 9,500	2	$ 19,000
	Contingencies				3,800
	AUXILIARY FISH SUPPORT ITEMS				
	Mobile Laboratory1/	Ea.	81,000	1	81,000
	Contingencies				16,200
	STRUCTURES				
	Mobile Home-Office1/	Ea.	6,000	1	6,000
	Contingencies				1,200
	TOTAL COST MOBILE EQUIPMENT				$127,200

1/ Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-24 - FISH REARING PONDS, DETAILED COST ESTIMATE, LAKE FRANCIS CASE

NORTH BAY AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	700	23,100
	Subtotal				28,100
	Contingencies				5,620
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement 1/				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	200	800
	Contingencies				160
	TOTAL COST SITE DEVELOPMENT				$318,360

1/ Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-25 - FISH REARING PONDS, DETAILED COST ESTIMATE, LAKE FRANCIS CASE
ST. PHILLIPS BAY

Description	Unit	Unit Cost	Estimated Quantity	Total Cost
05 FISH AND WILDLIFE PONDS				
Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
Excavation, General	C.Y.	1.50	23,090	34,600
Slope Treatment				
Cutoff Trench	C.Y.	3.00	6,200	18,600
Surfacing	C.Y.	8.00	69	600
Seeding	Ac.	400.00	1.8	700
Subtotal				69,400
Contingencies				13,880
FISH HATCHERY				
Waste Storage Vault	Job	L.S.	1	1,500
Electrical	Job	L.S.	1	10,000
Subtotal				11,500
Contingencies				2,300
CONTROL STRUCTURES				
Sluice Gate	Job	L.S.	1	5,000
Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	800	26,400
Subtotal				31,400
Contingencies				6,280
AUXILIARY FISH SUPPORT ITEMS				
Habitat Improvement[1/]				
Sprigging	Ac.	1,200.00	100	120,000
Seeding - 5 years	Job	L.S.	1	37,000
Subtotal				157,000
Contingencies				31,400
08 ROADS				
Roadway	L.F.	4.00	100	400
Contingencies				80
TOTAL COST SITE DEVELOPMENT				$323,640

1/ Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-26 - FISH REARING PONDS, DETAILED COST ESTIMATE, LAKE FRANCIS CASE

NORTH WHEELER AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	150	5,000
	Subtotal				10,000
	Contingencies				2,000
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	50	200
	Contingencies				40
	TOTAL COST SITE DEVELOPMENT				$295,920

[1/] Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-27 - FISH REARING PONDS, DETAILED COST ESTIMATE, LAKE FRANCIS CASE

SNAKE CREEK AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Waste Storage Vault	Job	L.S.	1	1,500
	Electrical	Job	L.S.	1	10,000
	Subtotal				11,500
	Contingencies				2,300
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	200	6,600
	Subtotal				11,600
	Contingencies				2,320
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement 1/				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	100	400
	Contingencies				80
	TOTAL COST SITE DEVELOPMENT				$299,880

1/ Not considered in computation of Engineering and Design and Supervision and Inspection.

Table F-28 - FISH REARING PONDS, DETAILED COST ESTIMATE, LAKE FRANCIS CASE

ELM CREEK AREA

	Description	Unit	Unit Cost	Estimated Quantity	Total Cost
06	FISH AND WILDLIFE PONDS				
	Excavation, Stripping	C.Y.	$ 2.05	7,260	$ 14,900
	Excavation, General	C.Y.	1.50	23,090	34,600
	Slope Treatment				
	Cutoff Trench	C.Y.	3.00	6,200	18,600
	Surfacing	C.Y.	8.00	69	600
	Seeding	Ac.	400.00	1.8	700
	Subtotal				69,400
	Contingencies				13,880
	FISH HATCHERY				
	Electrical	Job	L.S.	1	10,000
	Contingencies				2,000
	CONTROL STRUCTURES				
	Sluice Gate	Job	L.S.	1	5,000
	Pipe, 2-3/4ft. Dia. CMP	L.F.	33.00	500	16,500
	Subtotal				21,500
	Contingencies				4,300
	AUXILIARY FISH SUPPORT ITEMS				
	Habitat Improvement[1/]				
	Sprigging	Ac.	1,200.00	100	120,000
	Seeding - 5 years	Job	L.S.	1	37,000
	Subtotal				157,000
	Contingencies				31,400
08	ROADS				
	Roadway	L.F.	4.00	100	400
	Contingencies				80
	TOTAL COST SITE DEVELOPMENT				$309,960

[1/] Not considered in computatior of Engineering and Design and Supervision and Inspection.

Reach Designation Under National Wild and Senic Rivers Act

22. Even though the National Wild and Scenic Rivers Act (PL 90-542) imposes no requirement to demonstrate the presence of net benefits as measured solely in economic terms, the plan recommended in this report does, in addition to many benefits unquantifiable in dollars, show healthy economic justification. Average annual benefits stemming from visits to the river induced by the existence of reach designation and associated development, are more than five times the average annual costs, as discussed in the following paragraphs.

Costs

23. Project first costs for the acquisition of lands and interests in lands and for development of associated recreation facilities are Federal costs which will result from classification and designation of the project area under provisions of the Wild and Scenic Rivers Act. Interest during construction is not computed since benefits will accrue as construction is completed on individual segments of the project. Therefore, the investment cost equals the first cost. Annual costs include interest and amortization, operation, maintenance, and replacement. Federal responsibility for operation and maintenance will be limited to:

- Management of Federal recreation facilities now in place downstream of the dam at Gavins Point and of recreation easement lands identified at the close of Section E
- Maintenance of stabilization works placed riverward of the high banks to preserve outstanding features
- Annual real estate inspection of Federally acquired recreation and scenic easement lands and lands acquired in fee for

recreation development

24. Based on costs of similar projects, a contingency allowance of 20 percent on recreation facilities and 25 percent on lands and damages and river feature stabilization has been included in the project first cost. Costs for engineering and design of eight percent and for supervision and inspection of seven percent were included in the first cost of the recreation facilities and river feature stabilization. In lieu of E&D and S&I allowances for costs associated with lands and damages appropriate costs were included for administrative activities.

25. Operation, maintenance, and replacement costs were estimated on the basis of cost data experienced at similar types of recreation developments with similar intensities of utilization. The annual operation and maintenance costs for recreation lands and facilities approximate 12 cents per recreation day. Additional annual operation and maintenance costs include $67,500 for maintenance of the river stabilization features, for a total annual operation and maintenance cost of $148,350. The average annual value of future replacements is estimated at $17,450. Table F-29 contains a summary of capital and annual cost components. Detailed unit costs are presented in Table F-31 through F-38 at the conclusion of this subsection.

Benefits

26. The determination of recreation benefits was accomplished by the Bureau of Outdoor Recreation (BOR) as summarized below:

- The two basic items to be determined in computing project benefits are the number of project-oriented visitors (expressed in recreation days) and the value of each recreation day
- A recreation day, based upon observed data, is made up of two recreation activities, on the average
- Recreation days creditable to Wild and Scenic River Act designation are the difference between estimated visits to the river

Table F-29 Reach Designation PL 90-542
Cost Summary

FIRST COST		
Lands and Damages		$2,835,000
Lands	$ 300,000	
Recreation easement	1,000,000	
Scenic easement	200,000	
Contingencies 25%	375,000	
Administrative activities	960,000	
Recreation Facilities		2,630,000
Access roads	80,000	
Activity guides & controls	2,013,650	
Utilities	98,000	
Contingencies 20%	438,350	
River Feature Stabilization		1,350,000
Riprap slope treatment	660,000	
Stone training dikes	420,000	
Contingencies 25%	210,000	
Engineering and Design		318,400
Supervision and Inspection		278,600
TOTAL FIRST OR INVESTMENT COST		$7,412,000
ANNUAL CHARGES		
FEDERAL		
Interest @ 6-3/8%		$ 472,500
Amortization		22,500
Operation and Maintenance		104,200
Total Federal Annual Costs		$ 599,200
NON-FEDERAL		
Operation and Maintenance		$ 44,150
Major replacements		17,450
Total Non-Federal Annual Costs		$ 61,600
TOTAL PROJECT ANNUAL COST		$ 660,800

with and without such designation

● The value of a recreation activity (50 percent of the value of a recreation day) is the weighted average value of all recreation activities which will occur, based on analysis of comparable marketing areas.

27. The value of various general recreation activities in this region was established within the range of $0.75 to $2.25 as shown in Table F-30, while specialized recreation activities fall between $2.26 and $6.00. The average weighted value per recreation activity derived from this mix is $2.44, making the value of a recreation day equal to $4.88. The bulk of the specialized recreation activities is attributable to national awareness of a river segment now virtually unused.

Table F-30 EVALUATION OF RECREATION ACTIVITIES

Recreation Activity	Value per Recreation Activity	Percent Distribution	Weighted Activity Value
Picnicking	$1.10	12	$.13
Boating and canoeing	3.50	12	.42
Fishing	5.00	15	.75
Camping	2.25	10	.23
Swimming	.75	25	.19
Hunting	6.00	10	.60
Sightseeing	.75	16	.12
		100	$2.44

28. BOR estimates of increases in river-oriented visits attributable to the project start with an initial 500,000 recreation days in 1980, increasing to 750,000 recreation days in 1990. This level of visitation is estimated to be project capacity, and is anticipated to continue throughout the remaining 40 years of project life. Annual benefits then become the product of the number of recreation days accrued in a given year and the average value of one recreation

day ($4.88). Average annual equivalent benefits adjust for future increases in attendance and benefits by discounting them to their present worth.

29. Based on the procedures outlined above, the average annual equivalent benefits derived from designation of the Yankton-Ponca reach under provisions of PL 90-542 are $3,306,000.

Justification

30. The estimated annual costs are $660,800 compared to annual benefits of $3,306,000. This component of the selected plan is abundantly justified with a benefit-cost ratio of 5.0.

Table F-31 REACH DESIGNATION UNDER PL 90-542
DETAILED COST ESTIMATE

Land Acquisition

Item No.		Quantity	Unit	Total Cost
01	Lands and Damages			
	Lands			
	Cropland/Pasture	350	Acre	
	Islands	100	Acre	
		450	Acre	$ 300,000
	Recreation easement			
	Submerged	6,600	Acre	
	Wet bars	1,700	Acre	
	Green bars	1,500	Acre	
	Brush	1,200	Acre	
	Tree cover	1,100	Acre	
	Pasture	700	Acre	
		12,800	Acre	1,000,000
	Scenic easement	1,700	Acre	200,000
	Total lands and damages			1,500,000
	Contingencies 25% 1/			375,000
	Total lands & contingencies			$1,875,000
	Administrative activities	600	Tracts	960,000
	Total Estimated Cost of Acquisition			$2,835,000

1/ Includes severance damages on fee lands.

Table F-32 Reach Designation Under PL 90-542
Detailed Cost Estimate

South Dakota Downstream Area

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Access Road	1	Job	LS	$ 20,000
	Activity guides & controls				
	Parking areas (cars/trlrs)	50	Each	$ 270	13,500
	Parking circulation	1	Job	LS	1,500
	Campsites	100	Each	10,500	1,050,000
	Boat ramps (2 lanes)	1	Each	30,000	30,000
	Boat docks	1	Each	5,000	5,000
	Picnic areas	50	Each	2,000	100,000
	Utilities				
	Vault toilets	4	Each	7,000	28,000
	Subtotal				1,248,000
	Contingencies				249,600
	Total Cost Area Development				$1,497,600

Table F-33 Reach Designation Under PL 90-542
Detailed Cost Estimate

South Dakota Game Production Areas

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Activity guides & controls				
	Parking areas (cars/trlrs)	30	Each	$ 270	$ 8,100
	Boat ramps	2	Each	20,000	40,000
	Boat docks	2	Each	5,000	10,000
	Utilities				
	Vault toilets	2	Each	7,000	14,000
	Subtotal				$72,100
	Contingencies 20%				14,420
	Total Cost Area Development				$86,520

Table F-34 Reach Designation Under PL 90-542
Detailed Cost Estimate

Clay County (S.D.) Park

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Activity guides & controls				
	Parking areas (cars/trlrs)	25	Each	$ 270	$ 6,750
	Boat ramps	1	Each	20,000	20,000
	Boat docks	1	Each	5,000	5,000
	Utilities				
	Vault toilets	1	Each	7,000	7,000
	Subtotal				$38,750
	Contingencies 20%				7,750
	Total Cost Area Development				$46,500

Table F-35 Reach Designation Under PL 90-542
Detailed Cost Estimate

Island Development (2 sites)

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Activity guides & controls				
	Campsites, primitive	2	Job	LS	$20,000
	Trails	6	Mile	$5,800	34,800
	Utilities				
	Vault toilets	2	Each	7,000	14,000
	Subtotal				$68,800
	Contingencies 20%				13,760
	Total Cost Area Development				$82,560

Table F-36 Reach Designation Under PL 90-542
Detailed Cost Estimate

Nebraska Bluffs Area (3 sites)

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Access Roads	3	Job	LS	$ 60,000
	Activity guides & controls				
	Parking areas (cars/trlrs)	15	Each	$ 270	4,050
	Campsites	50	Each	10,500	525,000
	Campsites, primitive	2	Job	LS	20,000
	Boat ramps	1	Each	20,000	20,000
	Boat docks	1	Each	5,000	5,000
	Picnic areas (2 sites)	20	Each	2,000	40,000
	Trails	4	Miles	5,800	23,200
	Utilities				
	Vault toilets	4	Each	7,000	28,000
	Subtotal				$725,250
	Contingencies 20%				145,050
	Total Cost Area Development				$870,300

Table F-37 Reach Designation Under PL 90-542
Detailed Cost Estimate

Ponca State Park

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
14	Recreation Facilities				
	Activity guides & controls				
	Parking areas (cars/trlrs)	25	Each	$ 270	$ 6,750
	Boat ramps	1	Each	20,000	20,000
	Boat docks	1	Each	5,000	5,000
	Utilities				
	Vault toilets	1	Each	7,000	7,000
	Subtotal				$38,750
	Contingencies 20%				7,750
	Total Cost Area Development				$46,500

Table F-38 Reach Designation Under PL 90-542
Detailed Cost Estimate

River Feature Protection

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
16	Stabilization Works				
	Riprap slope treatment				
	Intermittent stone windrow	11,000	LF	$ 60	660,000
	Stone training dike				
	Hardpoints	4,000	LF	75	300,000
	Vane dikes	2,000	LF	60	120,000
	Subtotal				$1,080,000
	Contingencies 25%				270,000
	Total Cost Stabilization				$1,350,000

Summary

31. The economic performance of all plan elements discussed in Section F is summarized in Table F-39. The excess of total NED benefits over costs is greater than $26,000,000 annually, producing a benefit-cost ratio of 1.6. Apportionment of the investment cost to Federal and non-Federal interests is shown in Table G-2.

Table F-39 ECONOMIC SUMMARY
(Annual Benefits & Costs)

	Hydro-Power	On-Site Rearing Ponds	PL 90-542 Designation	Total
Benefits	$68,892,600	$ 1,080,000	$3,306,000	$73,278,600
Costs	45,622,000	363,300	660,800	46,646,100
Net Benefits	23,270,600	716,700	2,645,200	26,632,500
Benefit-Cost Ratio	1.5	3.0	5.0	1.6

SECTION G

DIVISION OF PLAN RESPONSIBILITIES

DIVISION OF PLAN RESPONSIBILITIES

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SECTION G

DIVISION OF PLAN RESPONSIBILITIES

1. In arriving at appropriate Federal and non-Federal responsibilities for implementing the various elements of the plan of improvement proposed herein, reliance has been placed on policies derived from various legislative acts adopted over a number of years. Although non-Federal interests have no direct responsibilities for implementing additional power facilities, the costs of these facilities are recovered through the revenue produced by the sale of the hydroelectric power generated. This policy of cost recovery was enumerated in the 1944 Flood Control Act and administrative policies stemming from it.

2. Historically, erosion control projects undertaken by the Federal Government have required local interests to provide lands, easements, and rights-of-way and to maintain the works after completion. This historic policy was most recently affirmed by PL 93-251, the Streambank Erosion Control and Demonstration Act, as further expanded by provisions in PL 94-578, the Water Resources Development Act of 1976.

3. Federal and non-Federal responsibilities for implementing various recreation components are specifically outlined by provisions contained in PL 89-72, the Federal Water Project Recreation Act - dealing with recreation at lake projects, by Section 4 of the 1944 Flood Control Act, as modified by Section 207 of the 1962 Flood Control Act - dealing with recreation at non-reservoir projects; and by PL 90-542, the Wild and Scenic Rivers Act - dealing with

designation of the Nation's rivers in three categories, Scenic, Wild or Recreational.

4. Application of these laws and policies to the various plan elements yields the requirements for establishing cost-sharing and other responsibilities which are outlined in subsequent paragraphs.

Federal Responsibilities

5. Federal responsibility for bank stabilization measures includes the obtaining of assurances from a non-Federal sponsor, followed by Federal funding and conduct of project design, construction, and subsequent periodic inspection. Other responsibility terminates with the end of the construction phase when the project is turned over to the sponsor for operation and maintenance. The differences which set this project somewhat apart from the ordinary are:

- Federal responsibility for every structure will be retained for a five-year period, at the end of which it will be turned over for local maintenance.
- Federal responsibility for problem areas in every reach will be retained for 20 years, at the end of which the reach should be tolerably maintenance free.

6. Additional hydro-power facilities recommended in this report constitute a wholly Federal responsibility, including funding, design, construction, operation, maintenance, and replacement to be undertaken by the Corps of Engineers. Marketing and transmission

of the power are also Federal responsibilities, accomplished in this region by the Bureau of Reclamation. That agency has the obligation to repay to the Treasury of the United States from system revenues funds sufficient to recover the allocated (in this instance, capital) costs of the improvements at the prescribed interest rate (currently 6-3/8) over a 50-year period, together with average annual maintenance, operation and replacement costs for these facilities.

7. Plan elements associated with recreational and environmental enhancement impose some variations in Federal responsibilities with variations in circumstance. Every proposal, however, does include project design, construction, and subsequent periodic inspection as a Federal commitment.

- Additional Federal responsibility for recreation access as an adjunct to bank stabilization includes obtainment of a non-Federal sponsor, and agreement to pay not more than one-half of the total first cost of the recreation development. The construction phase of any site terminates as soon as the element becomes operational and is turned over to the sponsor.
- In the development of fish rearing ponds, the Federal Government agrees to provide 75 percent of the total first cost and to undertake a five-year seeding program to revegetate the shoreline adjacent to the ponds. Other aspects of construction terminate as soon as an element becomes operational and is turned over to a non-Federal sponsor previously obtained.
- With the single exception of appropriate land use zoning, all initial effort associated with designation of the Gavins Point-Ponca reach under the Wild and Scenic Rivers Act will be a Federal responsibility. Federal funding will include costs for recreation and scenic easements, fee lands required for access and development, the development itself, and within-bank protective structures. Federal responsibility for operation and maintenance will be confined to the upstream terminal, already in place on Federal lands

below Gavins Point Dam; the rock structures provided for protection of riverine features within the high banks; and those fee and easement lands detailed at the end of Section E. All other segments will be turned over to a non-Federal sponsor as soon as they become operational.

8. Inasmuch as non-Federal interests would be unable to obtain Indian lands, should any be needed for project purposes, acquisition of such lands will be a Federal responsibility common to all elements of the recommended plan. To date, no need for such lands has been identified; should they prove necessary, however, they will be subject to the same reimbursement requirements as any other lands called for in the sponsorship arrangements.

Non-Federal Responsibilities

9. In order to implement the recommendations contained in this report a non-Federal sponsor will be required by administrative policy to accomplish certain items of local cooperation commonly referred to as the a b c's.

a. Provide without cost to the United States all lands, easements, right-of-way, and relocations necessary for the construction, and subsequent operation and maintenance of the project including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil and necessary retaining dikes, bulkheads, and embankments therefor, or the costs of such retaining works. Accomplish without cost to the United States all alterations and relocations of highway bridges, buildings, streets, storm drains, utilities, and other structures and improvements.

b. Hold and save the United States free from damages due to the construction works. As provided in Section 9 of the Water Resources Development Act of 1974, this shall not include damages due to the fault or negligence of the United States or its contractors.

c. Assume operation and maintenance of those elements previously identified for transfer from Federal responsibility upon completion of construction.

Non-Federal Requirements by Plan Element

10. Table G-1 summarizes, for each element of the recommended plan, the percentage of total first cost which non-Federal sponsors must assume, those portions of the a b c's which apply, and any limitations on such application. Although municipal water supply from the Gregory County pumped storage plant is omitted from specific recommendation in this report as a result of its late conception, declaration of intent has been received, and a parenthetical entry is included in the table to reflect local obligation if a water supply contract were executed.

Identification of Sponsors

11. **When the Phase I DM has resolved the issues which this report identified and marked for further study, the following will be provided:**

- Identification of those agencies of state and local government who have furnished the Corps of Engineers with assurances that local cooperation will be forthcoming for the functions of bank stabilization, recreation access, on-site rearing ponds, reach designation (and probably municipal water supply)

- Comments on the financial ability and legal capability of sponsors to assume their obligations.

Table G-1 NON-FEDERAL REQUIREMENTS

Plan Element	Percentage of Cost Sharing	Applicable a-b-c's	Limitations on a-b-c Application
Bank Stabilization	None except a-b-c's	a-b-c	O&M assumed 5 yrs after completion of individual structures; complete reach O&M assumed after 20 yrs of "seasoning"
Hydro-Power	No non-Federal responsibility		
River Access in conjunction with Bank Stabilization	50	a-b-c	O&M assumed immediately after completion of individual structures
Fish Rearing Ponds	25	a-b-c	O&M assumed immediately except vegetation by aerial seed, a Federal responsibility for 5 yrs.
Reach Designation under PL 90-542	0	b-c	No transfer of Federal responsibility for terminal below Gavins Point, protection of riverine features or maintenance of recreation easements
(Water Supply per 1958 Water Supply Act)	(100% of allocated cost)	(N.A.)	(Share O,M&R per cost allocation)

Cost Allocation

12. The requirement for a cost allocation exists only when reimbursable functions constitute part of a multiple-purpose project and make use of the joint facilities. The cost allocation then determines how these joint facilities will be allocated among reimbursable and non-reimbursable functions. Even though a project were to incorporate several reimbursable functions, a cost allocation would not be needed if only specific costs were associated with the performance of each function. Whether reimbursement occurs with Federal or non-Federal funds is immaterial to the cost allocating process.

13. Certain elements of this plan, namely fish rearing ponds and river access points are by precedent regarded as functions independent of multiple-purpose considerations, even though requirements for some repayment exists. While it is evident, for example, that fish from the rearing ponds are destined to reside in a multiple-purpose reservoir, allocation of some part of that reservoir's joint costs to the rearing ponds is an exercise both trivial and in conflict with the procedures followed in the approved Missouri River Main Stem Cost Allocation. Moreover, all joint costs of the system have already been distributed under the allocation; in the absence of new and sizable joint additions, reopening of that allocation now would serve little purpose. Another major plan element, bank stabilization, is also regarded as a specific measure which interacts with no multiple-purpose joint features.

14. Federally-financed hydro-power elements have a repayment requirement. In this plan, all expenditures for additional hydro-power

are specific to that function. No new joint use elements are proposed, but existing joint use facilities such as minimum pools and spillways do help to make possible the operation of new, as well as existing, hydro-power units. These joint costs, however, have already been identified and their allocation by function accomplished two decades ago. In this instance, as with the fish rearing ponds, reopening of the approved allocation does not appear useful.

15. In summary, expenditures to the functions recommended for service in this report are all treated as specific costs. To the extent required by law or regulation, these specific costs are proposed for repayment, cost sharing, or both but this procedure required no cost allocation.

Cost Apportionment

16. Table G-2 summarizes the distribution of estimated first cost and of annual operation, maintenance and replacement to Federal and non-Federal sources for the five recommended plan elements.

Table G-2 COST APPORTIONMENT
(In Million Dollars)

Function	Capital Cost		Annual Costs					
	Fed	Non-Fed	Federal			Non-Federal		
			I&A	OM&R	Total	I&A 1/	OM&R 2/	Total
Bank Stab.	23.0 3/	1.2	1.54	0.71	2.25	0.08	0.15	0.23
Rec Access	0.2	0.2	0.01	0	0.01	0.01	0.01	0.02
Hydro-Power	449.6	0	29.52	16.10 4/	45.62	0	0	0
Fish Ponds	3.2	1.1	0.21	0	0.21	0.07	0.08	0.15
PL 90-542	7.4	0	0.50	0.10	0.60	0	0.06	0.06
Total	483.4	2.5	31.78	16.91	48.69	0.16	0.30	0.46

Less	449.6	Costs reimbursable to the Treasury of the United States with interest (current rate is 6-3/8%)
Total	33.8	Non-reimbursable Federal capital costs

1/ Interest & Amortization

2/ Operation, Maintenance, & Replacement

3/ Includes $8.0 of stabilization work already authorized

4/ Includes $14.58 Annual Cost of Pumping Energy and $ .055 Recreation Loss